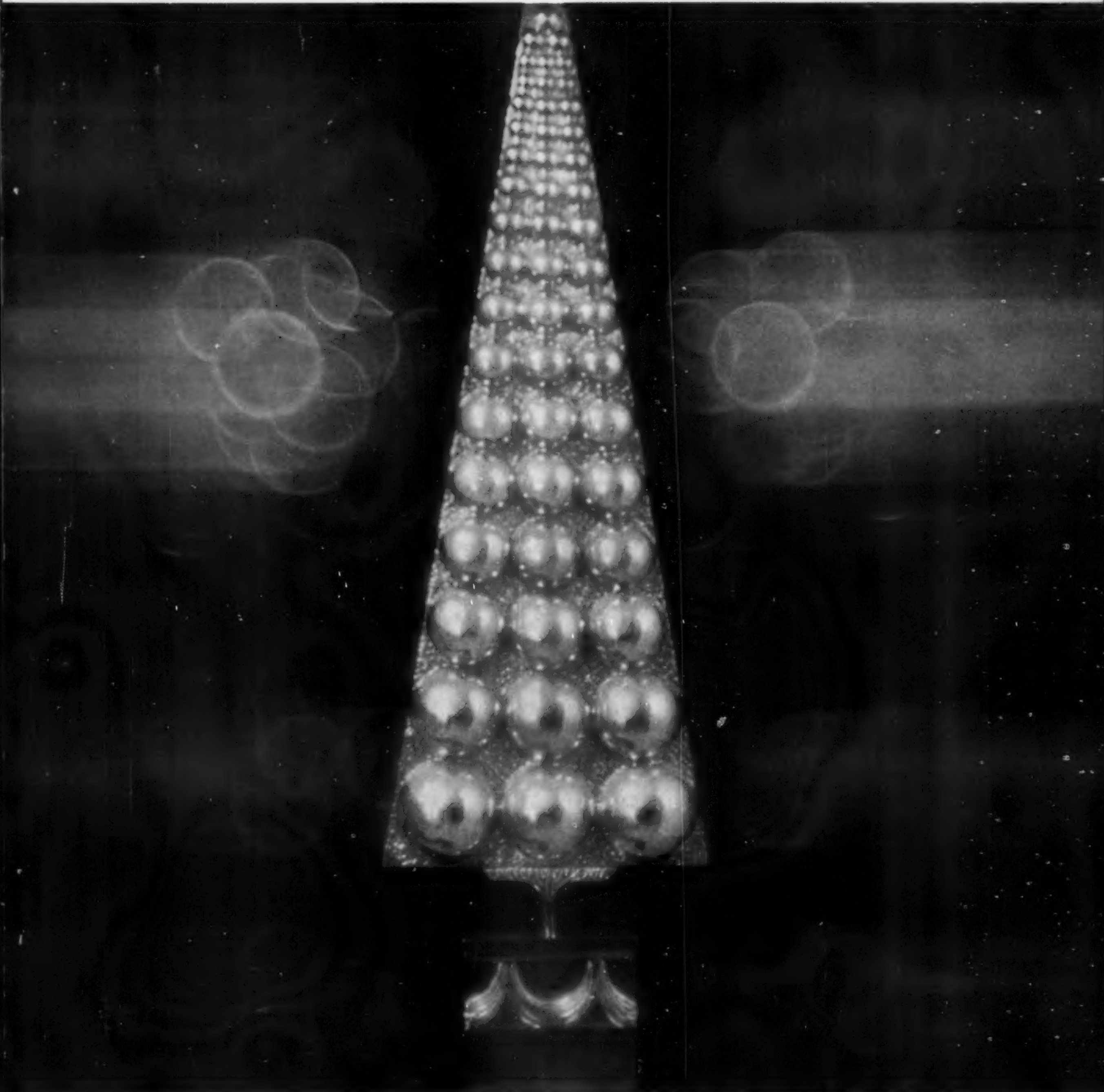
MODERN PLASTICS

DECEMBER 1960



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PLASTICS*

DECEMBER 1960
Volume 38 Number 4

Coming Up . . .

January is our traditional annual review issue. This year's materials review has been expanded to include reinforced plastics and some of the newer materials ... Engineering Section will report on results of a survey examining trends in machinery buying . . . Technical Section will develop a definitive bibliography of plastics developments in 1960 ... In the works: Fluorescent pigments for plastics . . . What you can do with chlorinated polyethylene . . . Two-tone butyrate sheet for signs . . . Nylon for small machine housings . . . Latest in special effects.

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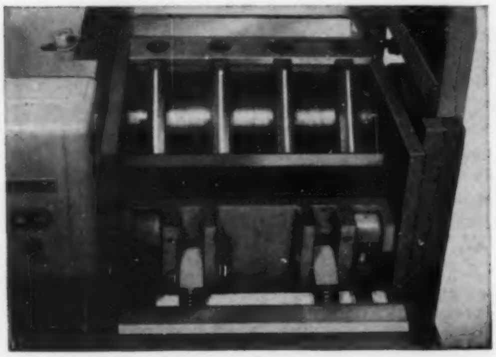
FIVE NEW

Cumberland

Large Throat

GRANULATING MACHINES



PART OF THE COMPLETE LINE OF CUMBERLAND PELLETIZERS, BESIDE THE PRESS AND CENTRAL GRANULATING MACHINES, DICERS, CHOPPERS AND PRE-BREAKERS

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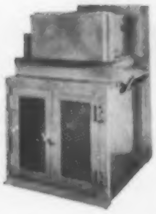

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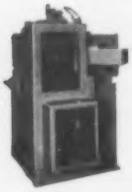

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Produces perfect cubes or pellets 1/16" to 1". Two standard sizes accommodate up to 7" and up to 14" ribbons.

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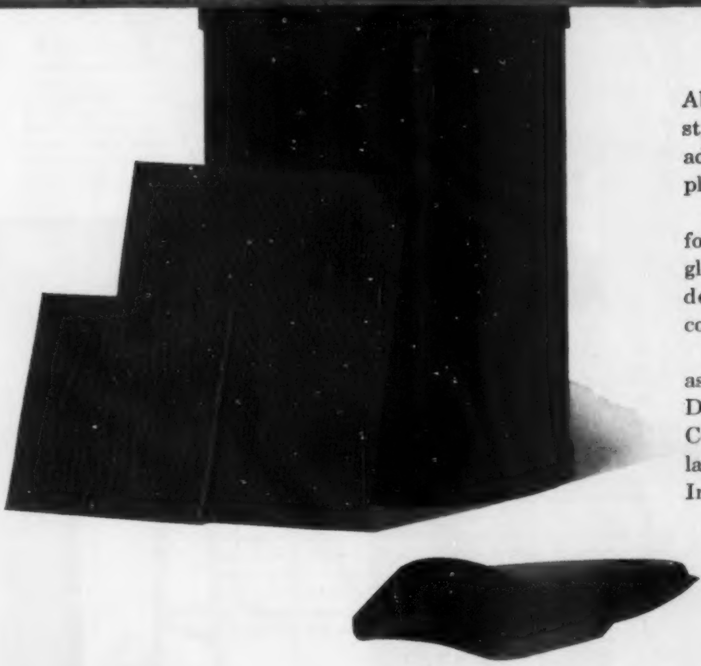

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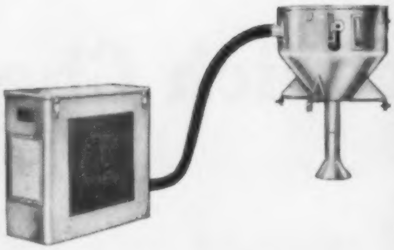

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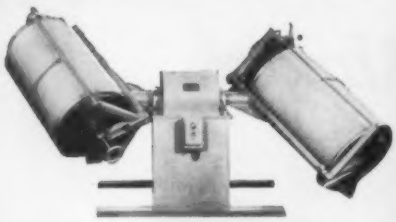

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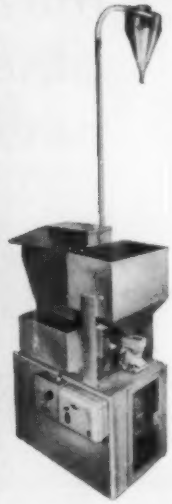
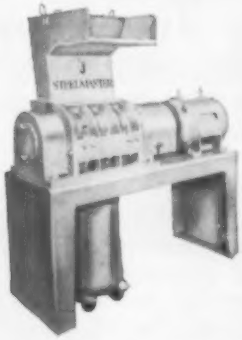


BLENDOMATIC GRANULATORS
Mix virgin material with regrind as the regrind is generated, then load mixed material into extruder or molding machine hopper.



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No wonder Amcel Fortiflex is creating a revolution in housewares, in toys, in parts for industry, in bottles and containers for packaging! Amcel representatives throughout the world will be glad to show you just how important this plastic can be in making better products and achieving economies in design and production.

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- Polyvinyl Acetate Emulsions

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- Arnel Triacetate (filament, staple, spun)
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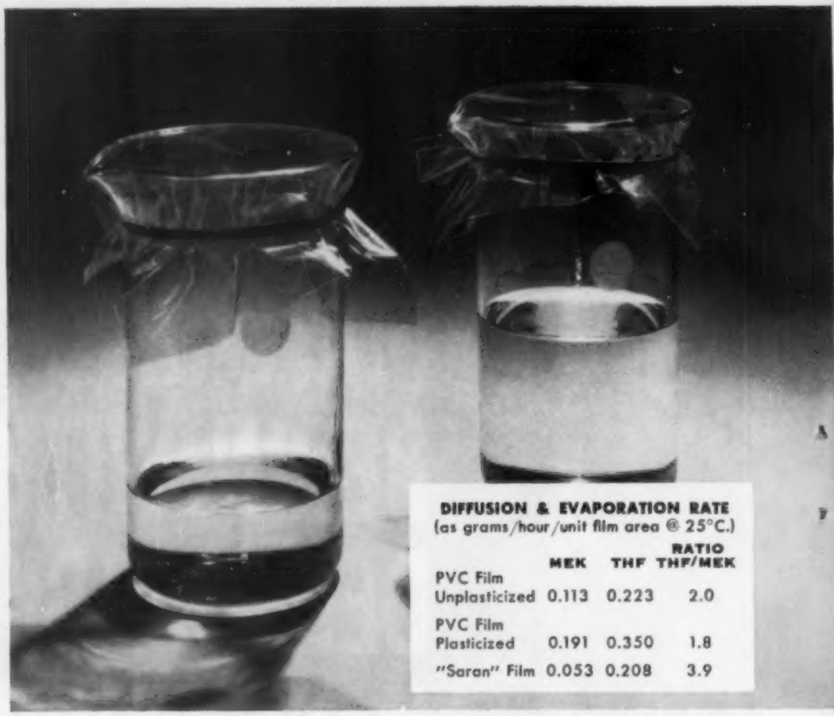

DIFFUSION & EVAPORATION RATE
(as grams/hour/unit film area @ 25°C.)

	MEK	THF	RATIO THF/MEK
PVC Film Unplasticized	0.113	0.223	2.0
PVC Film Plasticized	0.191	0.350	1.8
"Saran" Film	0.053	0.208	3.9

The two containers above were filled with equal volumes of THF (left) and methyl ethyl ketone (right). Each was covered with a PVC film and allowed to stand for an equal period. Results show THF diffuses through and evaporates from PVC films about twice as fast as MEK.

Save money, improve with Du Pont

THF HAS HIGH SOLVENT POWER

Even the highest molecular weight polyvinyl chloride resins dissolve readily at room temperature in Du Pont tetrahydrofuran—resins that are practically insoluble in other industrial solvents. High solids solutions at workable viscosities can be prepared, enabling users to take full advantage of the superior properties offered by such resins.

RESULT: *More durable vinyl coatings and films with improved resistance to abrasion, soil and chemical attack. Better adhesive formulations to promote higher bond strengths.*

THF HAS FAST DIFFUSION & EVAPORATION RATES

Du Pont tetrahydrofuran diffuses and evaporates more rapidly than a wide range of other commonly used resin solvents . . . up to 2 times as fast as ketone solvents (see above). Drying cycles are reduced, as are problems with residual solvent in coatings and films.

RESULT: *Coating and film casting machines can be run up to 2 times faster—you can produce the same work in half the time. Quality is improved, no tacky surfaces. Adhesives set much quicker.*

Du Pont tetrahydrofuran is available in 55-gallon drums, tank-wagon, and tank-car quantities. Orders may be placed with Du Pont's nearest Electrochemicals Department District Office.

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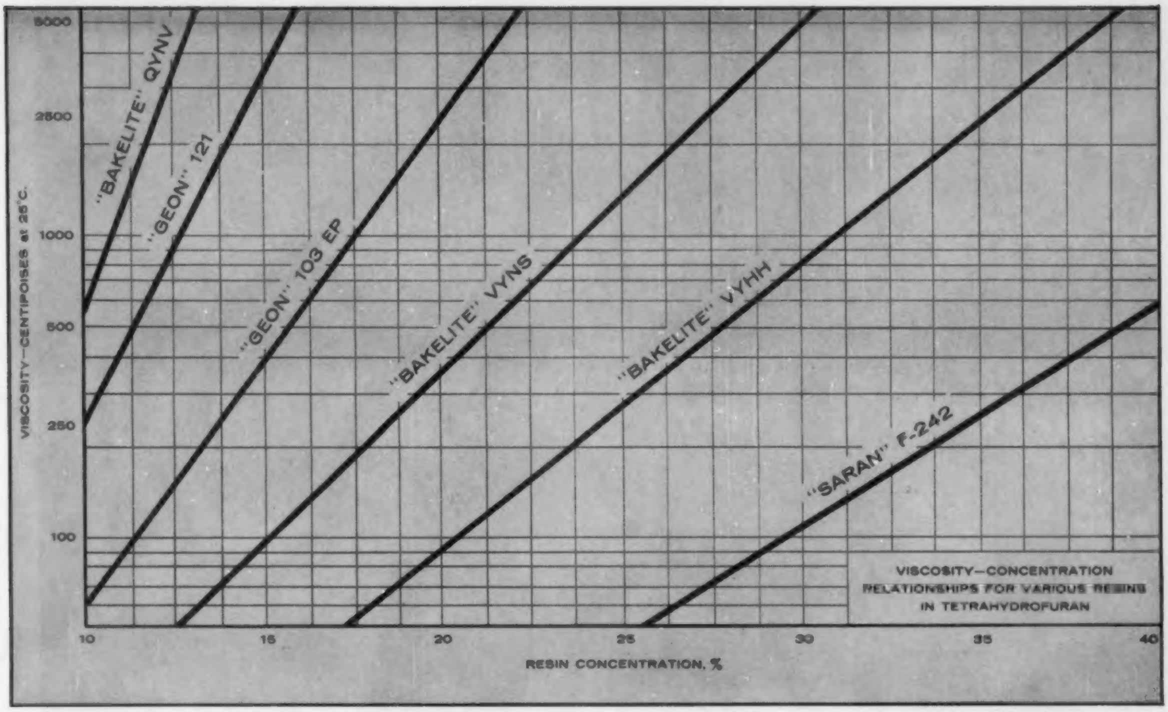

THF dissolves more PVC resin at room temperature than other solvents: The chart above shows the high percentage of various PVC resins which can be dissolved in tetrahydrofuran.

"Bakelite"—TM Union Carbide & Carbon Corp.
"Geon"—TM B. F. Goodrich Chem. Co.

vinyl product quality Tetrahydrofuran (THF)

THF IS EASILY RECOVERED

Up to 95% of tetrahydrofuran throughput can be recovered from coating, printing and film casting operations. Standard carbon adsorption units constructed of ordinary steel can be used to recover THF, whereas stainless steel equipment is necessary for recovery of many other solvents.

RESULT: *You are assured of minimum solvent loss—low recovery cost. Most existing systems can be modified easily and economically to recover THF.*

THF PROPERTIES

Appearance	Colorless, mobile liquid
Odor	Etherlike
Molecular weight	72.10
Freezing point	-108.52°C.
Boiling range	65°-67°C.
Specific gravity (20°/4°C.)	0.888
Weight, lb./gal. (20°C.)	7.4
Flash point (Tag closed cup)	6°F.

Vapor pressure, mm Hg. at:

15°C	114	45°C	385
25°C	176	55°C	550
35°C	263	65°C	760

Surface tension, dynes/cm. (25°C.) 26.4

Solubility. . Miscible with water, soluble in most organic solvents

Use THF to get greater savings and improved quality for all your vinyl products whether they be coatings, films or adhesives. We'll be glad to work with you in developing your particular application for this remarkable solvent. For more information on THF, just drop a line to Du Pont at the address below:

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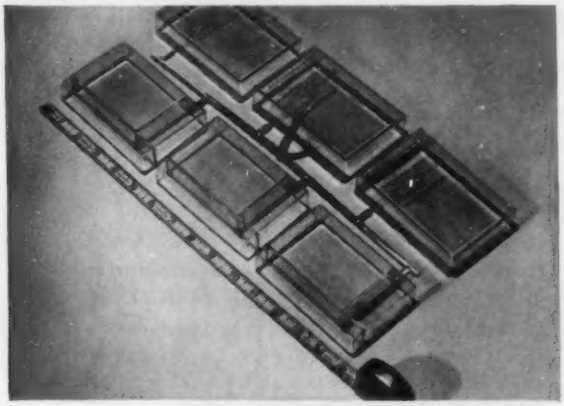
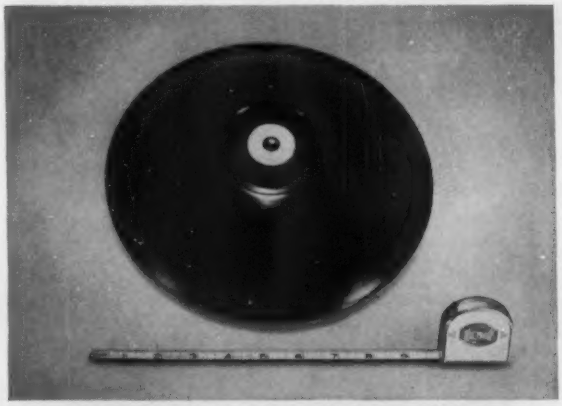
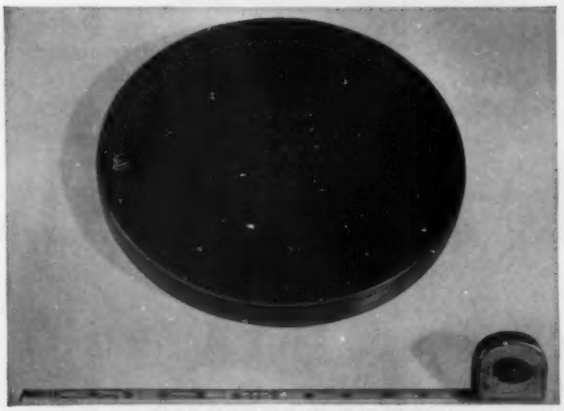
6-cavity box mold by North Star Industries, Minneapolis. Polystyrene shot weighs 6 oz. over a projected area of 90 sq. in.

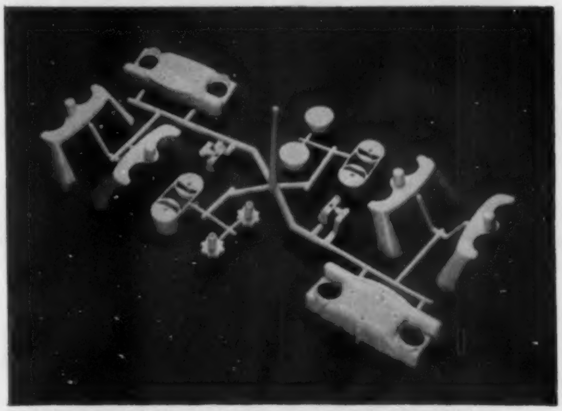


4-oz. Polystyrene Ice Bucket Lid is molded by Air Light Products, Omaha, Nebraska. Projected area is 78½ sq. in.





6-oz. Polyethylene Lid also molded by North Star Industries. Projected area of this 12" lid is 113 sq. in.



6.35-oz shot of rigid polyethylene produced by Trimold, Inc., on a 36-second cycle, molded for Fisher-Price Toys, Inc.

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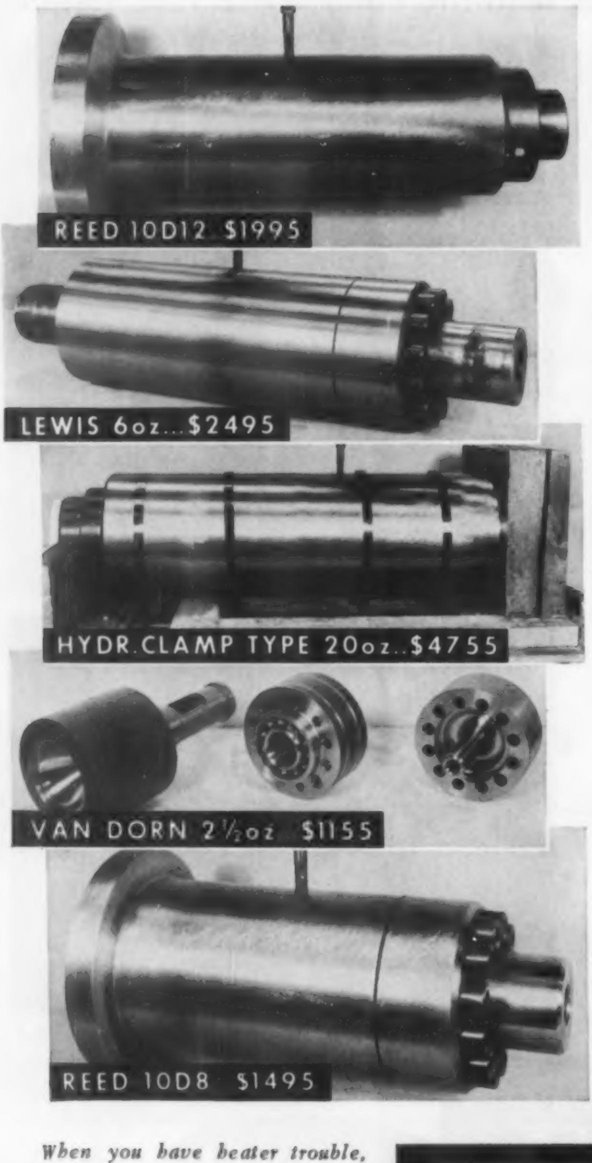

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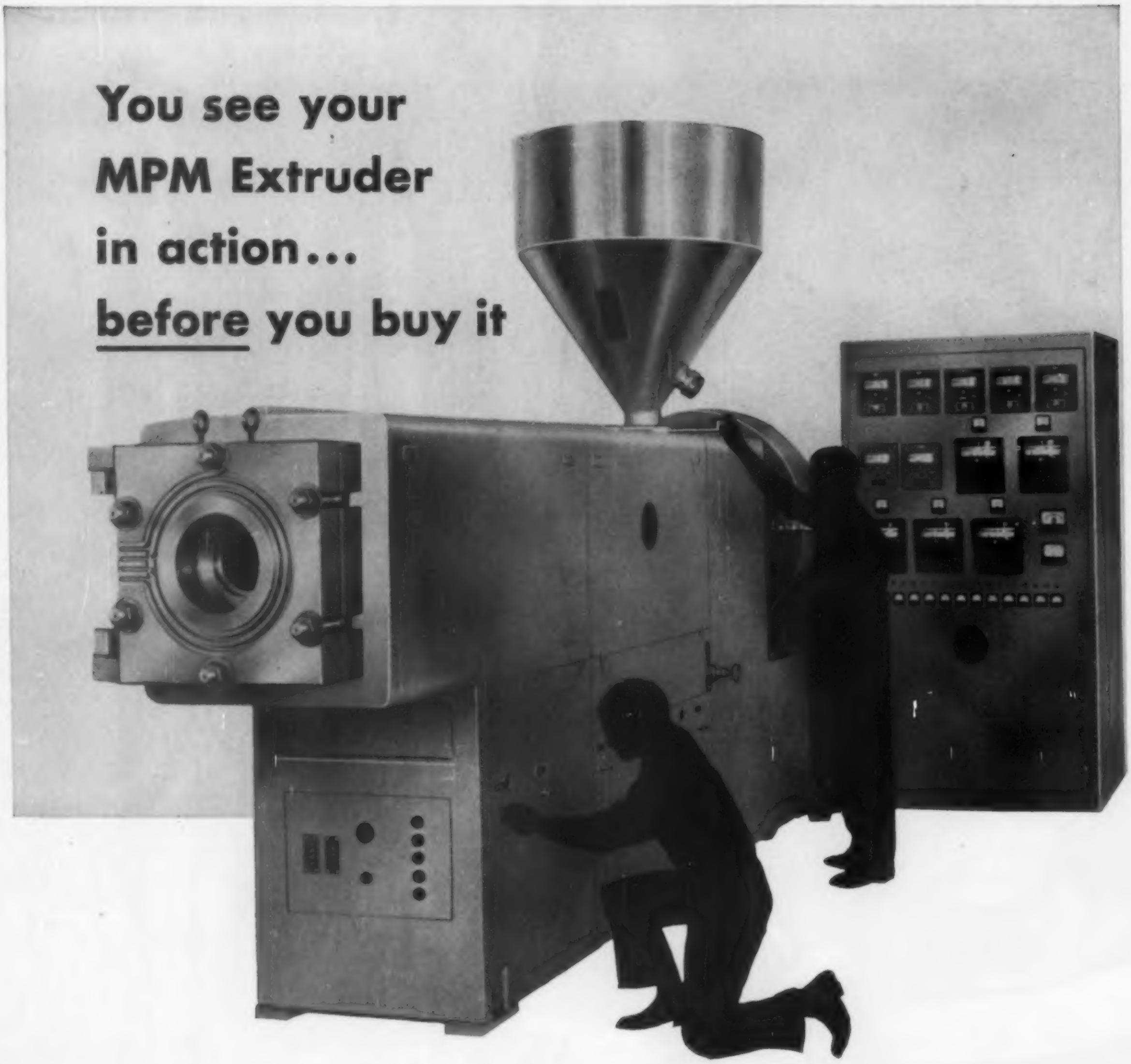

MPM doesn't sell merely extruders — it sells *production*. When you order an MPM extruder, you know exactly what caliber of performance you can expect, because you've seen it perform . . . had a chance to test every part before purchase.

Moreover, many extruders today are "patch-quilt" affairs: one piece made by this company, a second part by that, a third by still another. Not with MPM. For MPM manufactures virtually all its own components: grinds its own screws, assembles its own controls . . . all precision-built to MPM standards in MPM's modern, 90,000 sq. ft. plant.

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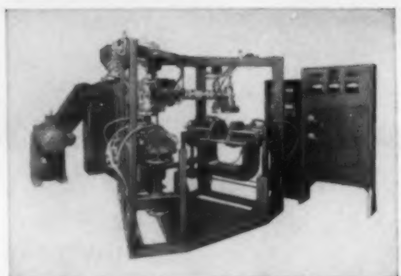

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for industrial finishes...plastics

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PLENCO

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"IF you can't stand the heat," according to an old political axiom, "stay out of the kitchen."

Housewives all over the country know that Sunbeam Corporation, Chicago, Ill., builds modern cooking appliances with handles that not only can "stand the heat", but help make a woman's daily tour of duty in the kitchen more pleasurable and productive.

Among these appliances, the Sunbeam Automatic Electric Frypan has long led in a new concept of rangeless meal preparation. Outstanding Sunbeam Frypans feature controlled even heat determined by a dial housed in the handle itself. Phenolic-molded, the handle stays cool and attractive. To make sure it does, Sunbeam engineers use a Plenco molding compound (Plenco 423) that provides the ideal combination of required properties: heat resistance, electrical insulation, dimensional stability, moisture and acid resistance, plus production factors assuring ease and economy.

Ready-made or specially made, there's a wide range of Plenco molding compounds available. They're use-proved in a number of additional applications by Sunbeam and by Sunbeam's Oster Division . . . as well as countless other successful applications in industries as varied as are the compounds themselves. Want to learn more about the advantages for *you* with phenolics by Plenco? We're ready to show you.

PLASTICS ENGINEERING COMPANY
Sheboygan, Wisconsin

Serving the plastics industry in the manufacture of high grade phenolic molding compounds, industrial resins and coating resins.

How reinforced plastics molders and high pressure laminators save time, work, material, money with Phenopregs*

1. Phenopreg prepregs simplify molding operations. Only one material—containing both resin and reinforcement—is used. This eliminates the need for weighing, mixing and hand-applying the compounds. Also the need for resin-reinforcement ratio control.

2. Phenopregs reduce hand labor. Elimination of hand dispersion of resin is one means. Use of custom-slit, sheeted and die-cut Phenopregs is another. And, where simple shapes are to be molded, roll material can frequently be fed right into the dies, for still a third saving of labor.

3. Phenopregs make mass production possible. By eliminating the lengthy process of hand impregnation, and, in the case of hand layups, by eliminating slow production cycles due to long periods for curing, Phenopregs speed up output, improve delivery schedules.

4. Phenopregs mean cleaner molding operations. They eliminate the need for cleaning up after wet molding, saving time, labor.

5. Phenopregs reduce waste. This is because there is no spillage and no mold overflow.

6. Phenopregs cut storage and handling costs. Because only one material has to be stored and handled, Phenopregs greatly reduce costs for these items.

7. Phenopregs produce better products. Phenopregs are superior because they enable the molder to (a) keep a uniform resin-reinforcement ratio throughout his laminate; (b) exercise strict control over the resin content; (c) control the cure because of the even dispersion of curing agents; (d) avoid defect-producing trapped air pockets or tiny air bubbles; and (e) eliminate the harmful effects of moisture . . . since the Phenopregs come predried.

8. Phenopregs build business. Phenopregs open new marketing opportunities by creating improved products—products more desirable because their physical, chemical, mechanical and electrical properties are always consistent.

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Electrical and Mechanical Applications. Fabricon offers you a full line of phenolic impregnated papers that meet or exceed NEMA and Military Specifications.

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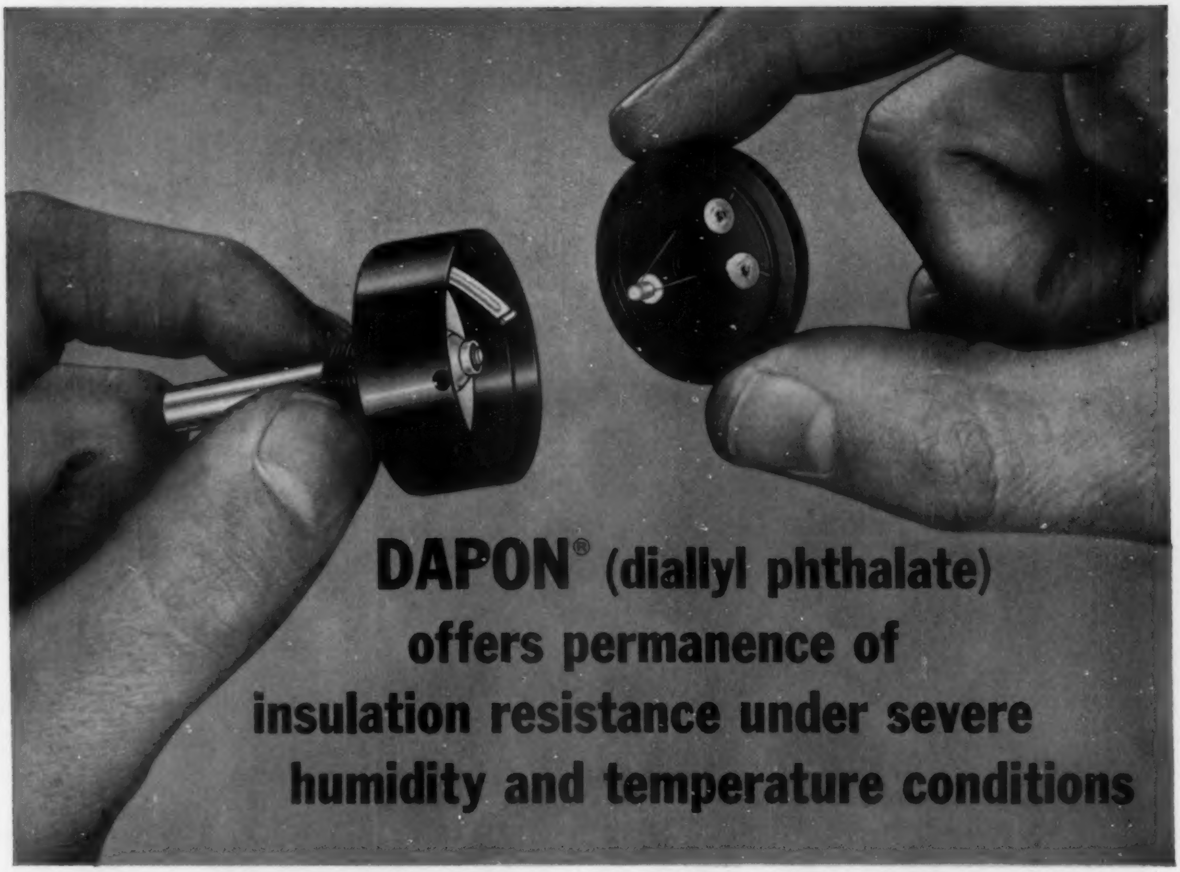

This plastic is ideal for applications where changes in humidity can affect electrical values. DAPON can prevent costly "in service" failures in electrical and electronic components.

A new molded plastic potentiometer produced by New England Instrument Company features exceptional resistance to humidity, high reliability and low noise. A raised conductive plastic ring is used in place of resistance wire in these miniature units. The new potentiometers are ideal for servo and instrumentation applications where long life and extreme accuracy are important factors.

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New England Instrument chose DAPON because of its superior electrical and physical properties, and its low moisture absorption. DAPON also molds easily around metal inserts without cracking, and withstands extremes of temperature, vibration and shock.

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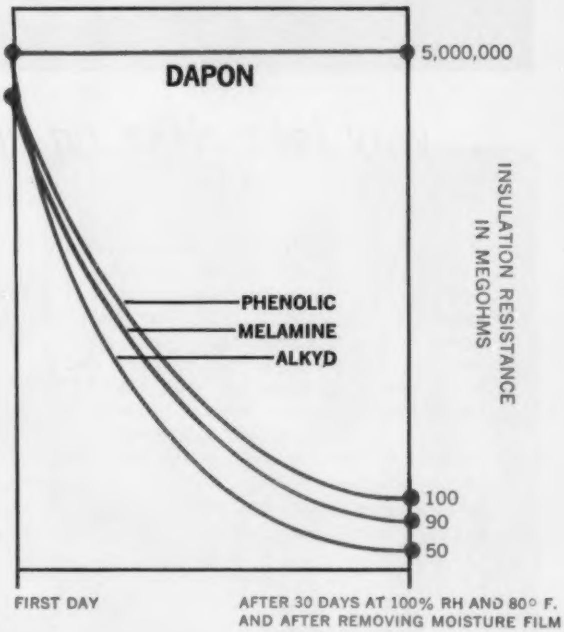
Write for FMC's data sheet containing technical information about DAPON, suggested uses for this resin, and the names of DAPON compounders.



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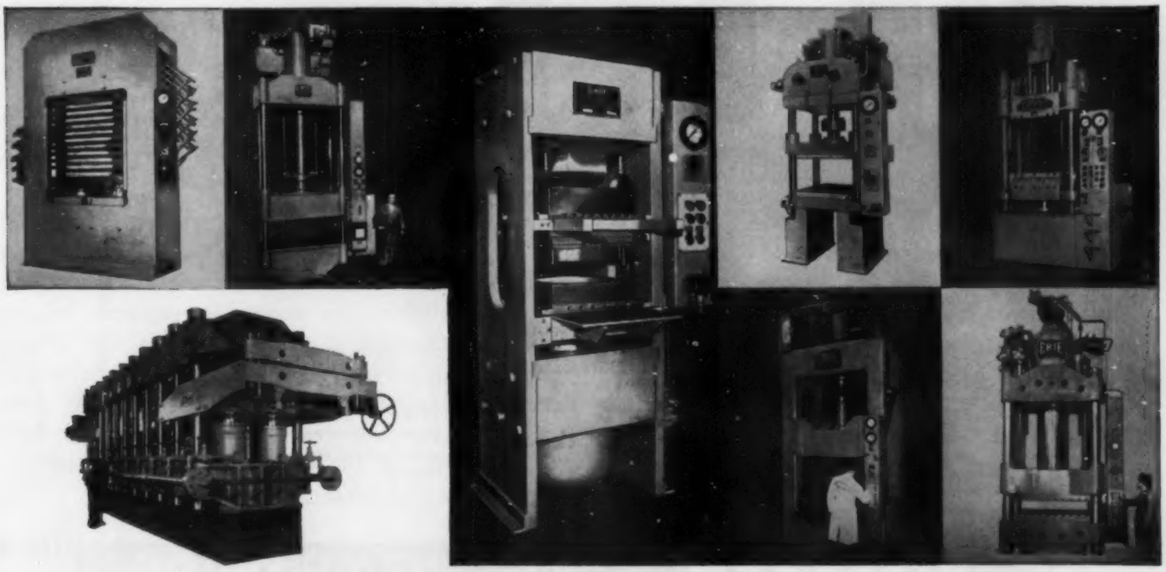

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*MARLEX is a trademark for Phillips family of olefin polymers.

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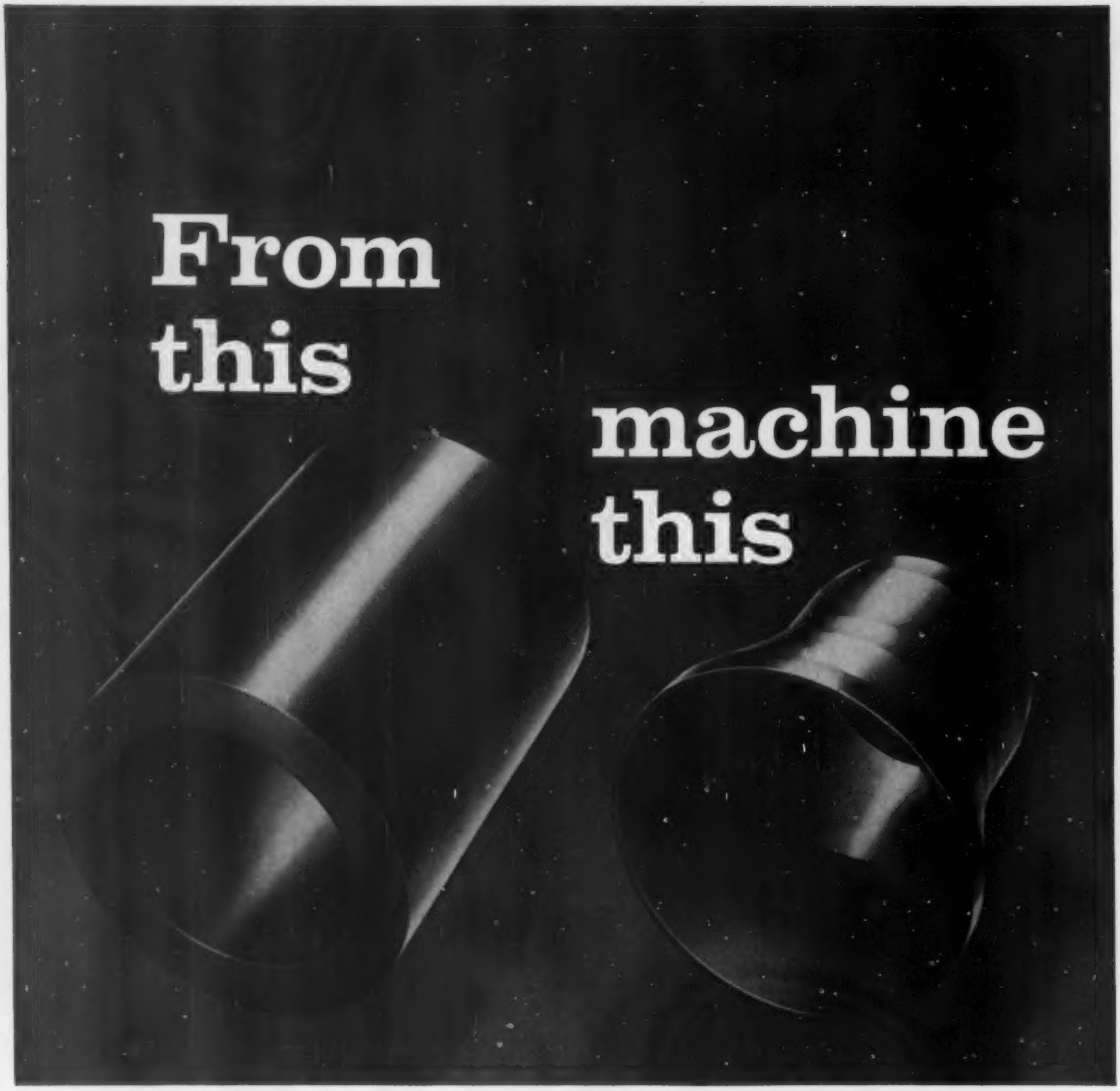

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High-temperature parts made from this molding compound exhibit controlled ablation, good structural strength, excellent thermal-insulating properties, and low thermal diffusivity. Extra-long spinning-grade asbestos fiber provides unusual physical stamina and contributes to high strength-to-weight ratio.

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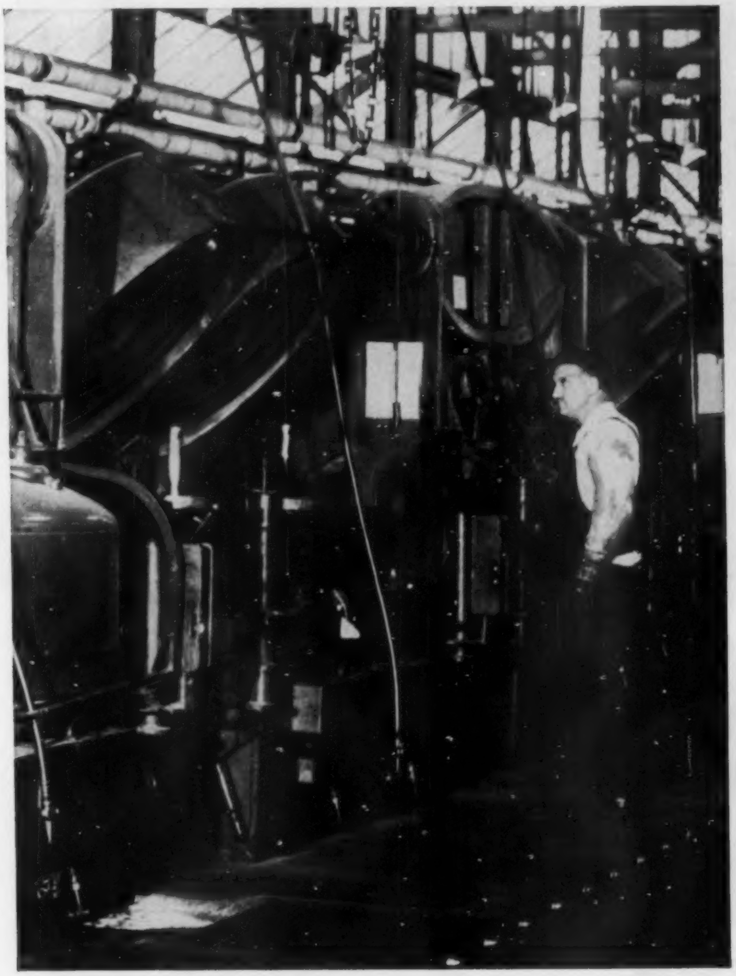
SILICONE NEWS from Dow Corning

Keep Production Moving



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Let Dow Corning field engineers help you select the silicone mold lubricant best for each application in your plant.

Other Cost-Cutting Silicones that can save you time are silicone electrical insulation for mill and mixer motors; silicone paints that withstand heat, oxidation, and weathering; Silastic® gums and bases for compounding silicone rubbers for unusual service; and Syl-off® coated paper as interleaving sheets in slab molding polyurethane and as a "no-stick" packaging material for sticky products. Write for full information today. Address Dept. 5612.

Silicone Mold Lubricants Give Fast, Clean Release with Minimum Build-up

Rubber and plastic products break away FAST and CLEAN from molds made "stick-free" with Dow Corning Silicones. These job-proved parting agents prevent sticking; assure good reproduction of fine surface detail; prevent tearing; keep rejects to a minimum.

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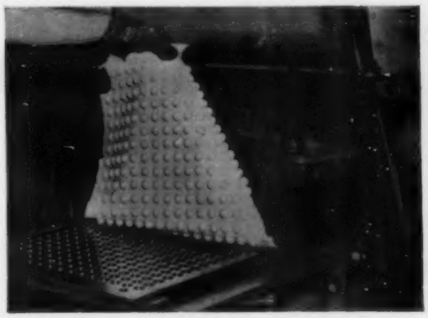
In short, Dow Corning silicone mold lubricants help you mold superior products—help you maintain economical high speed production.



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There are some powerful reasons why more and more manufacturers are making their products from Deeglas reinforced plastics. Few other materials offer so many advantages to the manufacturer and his customers—its strength, its lightness, its toughness, and all-the-way-through beauty. Deeglas reinforced plastics won't corrode, won't catch fire easily, won't damage easily; resist most chemicals, acids, sea water, marine growths and fungi; they mould cleanly to new shapes—create exciting design possibilities, take colour all the way through, and shrug off knocks and bangs that would damage other materials.

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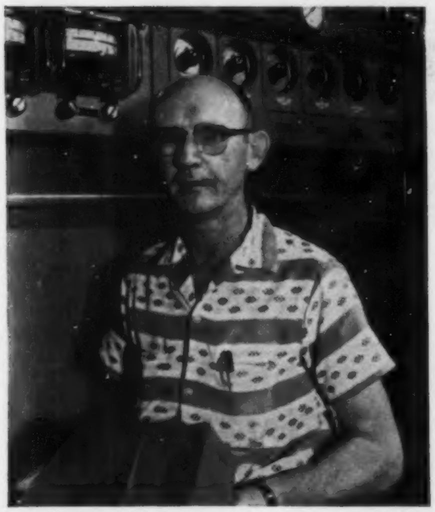
Aladdin Molds Picnic Snack Box and Cover on the Natco 300

"We Like the Versatility of Natco's Hydraulic Mold Clamp"

. . . Says Charles Allen, Molding Foreman at Aladdin Industries



"As manufacturers of vacuum bottle and snack box accessories, our molds require unusual clamping cycles. We find that Natco's straight hydraulic clamp gives us precise control of mold position and mold opening and closing speeds. Interrupted or delayed action of the clamp presents no problem with our Natcos."

Mr. Allen, Foreman at Aladdin Industries, Inc., Nashville, Tennessee, says, "Having the controls for hydraulic, temperature and time within easy reach of the operator is a real convenience. Our operators like to run the Natcos because of these features."

For complete information on Natco 12 to 140 oz. Injection Molding Machines write for Catalog 2001.

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NEW

THE PLASTISCOPE*

News and interpretations of the news By R. L. Van Boskirk

Section 1 **December 1960**

Rexall announces marketing and production program. Expansion of Rexall Chemical's East Coast Seamco and West Coast Granada polystyrene facilities and addition of impact styrenes to its lines in January have been announced by Ralph Knight, president of the company. The Seamco and Granada brand names will be dropped and the designation "Elrex" will henceforth be used as a tradename for Rexall plastics. The company is also planning a new manufacturing unit, with an initial capacity of 25 million lb., where styrene polymers and copolymers will be produced. This facility is expected to come on stream sometime in mid-1961. This unit will serve the Midwest, where 46% of the total polystyrene volume was sold in 1959. A. Schulman Inc., with six district offices, was named as national sales agent for the polystyrene line.

Resale of all varieties of conventional and linear polyethylene by Rexall as of this date has also been announced by Carl Setterstrom, vice-president of marketing. The resale set-up will be supported by Rexall's own technical service which is headed by Ken Kaufmann, formerly of Amoco and Spencer, and Charles Kucher, formerly of Spencer. The El Paso Rexall polyolefin plant, with a previously announced capacity of from 150- to 200,000 lb., is scheduled to go on stream in the first quarter of 1962.

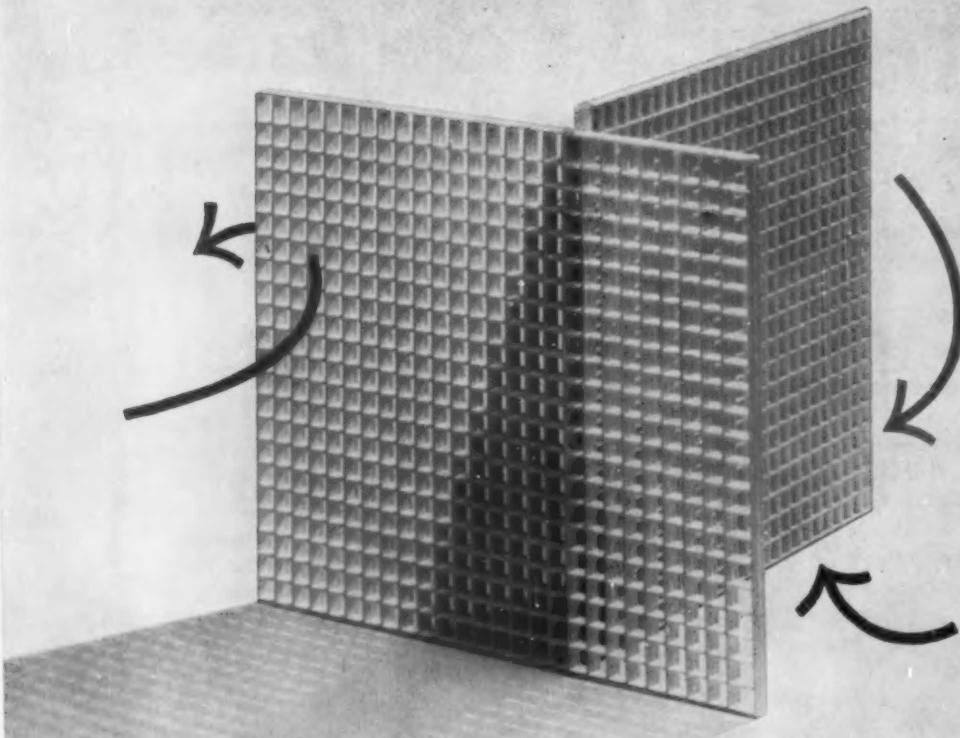
Regional sales set-up. Rexall has established three regional sales offices to market polystyrene and polyethylene. Eastern regional sales manager is William J. Monahan, headquartered in Holyoke, Mass. He had been sales manager for Seamco Chemical. Midwest regional sales manager is E. D. Boldt, with headquarters in Chicago. He was previously Midwest district manager for the plastics division of Spencer Chemical. The Western regional sales manager—in the area west of the Rockies, plus Texas—is F. W. Troester, with headquarters in Beverly Hills, Calif. Mr. Troester had been Western district sales manager for Minnesota Mining & Mfg. Co.

W. R. Grace expands in three areas. Evidence that W. R. Grace & Co. soon expects to become a major factor in plastics production is indicated by the recent announcement of vice-president E. E. Winne that the company 1) will add high-pressure processed polyethylene to its line of low-pressure material, 2) increase its capacity to produce the latter, and 3) plans to handle the polystyrene produced by its Texas subsidiary, Cosden Petroleum Corp.

Cosden will increase its production capacity, which will include medium- and high-impact as well as general-purpose formulations. The last listing of Cosden's capacity for polystyrene was 20 million pounds.

The high-pressure low- and medium-density polyethylenes to be sold by Grace will be polymerized by U. S. I. at its Pasadena, Texas plant to Grace specifications from ethylene supplied by Grace. The high-pressure-produced resins will range in density from 0.912 to 0.937 with melt indices from 0.3 to 70.0. The company's capacity for producing low-pressure (linear) resin

*Reg. U. S. Pat. Off.



was increased by 50%, which should give it an estimated capacity of over 70 million lb. Obviously, Grace expects demand for linear polyethylene to increase enough to overtake today's estimated capacity of around 300 million lb.; consumption in 1960 is estimated at around 180 million pounds. Grace expects its new resins to find ever growing markets, particularly in blow molding and vacuum forming. The addition of conventional polyethylene to its line is a policy that seems to have become necessary to almost every polyethylene producer in order to serve his customers satisfactorily. Adding polystyrene to the company line improves its position with processors, particularly molders, who are generally in the market for various thermoplastic formulations.

Mylar price reduction. The sixth consecutive price reduction for Mylar polyester film has been announced by Du Pont. Type C in 0.0025 (¼-mil) to 0.0035 gages is reduced by 25¢ lb., or from \$3.90 to \$3.65/lb. for ¼-mil and from \$3.40 to \$3.15 for 0.0035. It is used primarily for dielectrics in capacitors. The 0.0075, a release sheet, is reduced from \$2.50 to \$2.35.

Type A, or ½-mil, is reduced from \$2.50 to \$2.30. This film is used for typewriter ribbons, surfacing for acoustical tile, and other laminates and stationery supplies. The 3-mil to 10-mil sheet is reduced from \$1.80 to \$1.55. This is used primarily for wire and cable insulation and drafting film, with the heavier gages for motor insulation and spring roll shelving. The new plant in Florence, S. C., will start production this spring and its capacity will be double that of the Circleville, Ohio facility.

Mylar to take another space ride. An attempt to orbit another 140-ft.-diameter inflatable satellite will be made early in 1961. The technique will be similar to that used for Echo I, *i.e.*, the folded satellite will be launched to somewhat under a thousand miles and then inflated in space.

The new experiment is the first attempt at a rigidized sphere to overcome the effect of solar energy which tends to collapse the balloon and wrinkle the surface. In order to achieve a tensile modulus about 10 times that of the Echo I skin—which was ½-mil Mylar polyester with a micro-thin layer of aluminum deposited on it—the new skin will be ½-mil Mylar to which is laminated ¼-mil layer of aluminum foil. This thicker lamination will be much stiffer and more resistant to solar energy, according to the producer, Schjeldahl Corp.

Profitless price peregrinations. The price of general-purpose vinyl chloride resin is now listed at 18½¢, down from 20½ cents. The polymer price has slipped from 23½¢ in early 1959, first to 20½ and now down to 18½. In 1957 it was 30 cents. Suppliers assert that: there is now no margin of profit left for development and research to probe for new and expanded markets; there will be no money to prevent obsolescence; present resins will become obsolete with no money to develop a replacement; and markets may be lost to competitive materials. There is no indication that the wrecked price structure for vinyl chloride resin in 1960 was due to a desire to broaden the market by finding new outlets. If so it hasn't worked as yet. Total resin sales will be slightly less than in 1959, when volume reached 874 million lb. At one time, during 1959,

resin was actually scarce. That year's volume was a 230-million-lb. increase over 1958, an almost unbelievable achievement. But it boomeranged. Motivated by a false belief that the industry could continue to increase by such astronomical sales, many of the producers in the 10- to 50- or 60-million-lb. volume class hastened to expand—now they want to be 50- to 100-million-lb. producers at least. As a result, capacity has been rapidly increased during 1959 and may reach 1.4 billion lb. in 1961. Some of the excess production in 1960 has been sold by the age-old custom of offering goods at less than standard price. The 18½¢ price was probably aimed at the so-called price cutters. Maybe this low, almost profitless price will jar the industry to its senses and result in price stabilization—no one, including the customer, profits from a price war among the companies who fill the pipe line.

Oriented nylon sheet increases belt life. Industrial conveyor belting, with a core of extruded and oriented nylon sheet, is being placed on the market by Goodall Rubber Co., Trenton, N. J. The core is produced by Moldings & Extrusions Inc., Wauregan, Conn., who pioneered and developed the exclusive process whereby nylon-6 can be oriented in wide sheets of varying gages. The Moldex sheet, produced in widths up to 16 in. and in length to meet market requirements, has a tensile strength up to 40,000 p.s.i. The 20- to 60-mil-thick nylon core replaces fabric with 3 plies or more. At present, it sells at a premium price for special jobs but will come down when volume increases.

The finished conveyor belting has been extensively tested in rough jobs such as moving rocks, coal, etc., where it has outworn previously accepted belts by from 50 to more than 100 percent. Moldex belting, made from oriented polypropylene, whose lower cost is an advantage, is also being tried for food conveyors.

New developments in Vexar. Polyolefin netting produced by Du Pont is now being studied as a possible replacement for steel mesh used in chicken coops . . . a high-density PE hat form for millinery is another offering that could also be used for industrial packaging . . . garment stiffeners for form-fitting or foundation garments are another possibility . . . and an example of its use in Christmas decorations is illustrated on page 88 of this issue.

What may be a large-volume application is Vexar for carpet backing, where jute is now used. The market for jute in this field was around 50 million lb. in 1959. The plastic has no moisture pick-up and bugs don't like it. It could result in a thermoformed carpet in complex forms. It is wearable, won't stretch, and is washable.

Vexar net for separator sheets is useful in industrial packaging—it serves as cushioning and prevents items from rubbing. As a shelf lining it gives glasses a chance to drain in restaurant equipment.

Chain stores are about to use it as a packaging for onions, to slow down sprouting proclivities. Du Pont now has an oriented netting to give greater strength. Cost is cut because of thinner strands. Useful in 3- and 5-lb. bags for candy, produce (potato bags are a likely development), etc., Teflon FEP, Delrin, and nylon are now being tried in laboratory tests in this extruded netting development. (To page 47)

TITANOX® helps bring smiles to the kitchen

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For TITANOX pigments, particularly TITANOX-RA, help maintain efficiency in production and uniformity of white and light colored products that make consumers happy.

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THE PLASTISCOPE

Polypropylene—more coming—higher heat resistance. Shell Chemical will build an 80-million-lb. polypropylene plant in West Deptford Township near Woodbury, N. J., south of Philadelphia. Shell claims to have developed a new process from research work at the Emeryville, Calif., plant. Total announced polypropylene production capacity for 1961-62 is now estimated at from 300 to 400 million pounds.

Two new grades of sustained-heat polypropylene polymers have been introduced by AviSun Corp. Grade 1041 is for pipe and tube extrusion. Grade 1044 is for injection molding of hot water-detergent appliance parts in dishwashers and clothes washers, automotive components, and electronic parts.

An error of transmission in a comparison of the polypropylene film with that of polyethylene film was printed in this column last month. The correct statement is that "polypropylene is said to give the same strength at 1 mil that polyethylene does at 1¼ mils."

Goodrich-Gulf Chemical's linear polyethylene. The company's new "Ameripol," developed from the Ziegler activated-catalyst system to be produced at the plant now under construction at Port Neches, Texas, is said to impart new highs in resistance to environmental stress cracking and in resistance to temperature embrittlement, while maintaining ease of processing. Thus, it is well-suited for blow molding, wire and cable insulation, extruded pipe. Addition of an anti-oxidant will double the stress cracking resistance. Quality control features built into the Goodrich-Gulf process are said to assure product uniformity so that the resin may be depended upon to behave predictably in compression or injection molding, extrusion, or blow molding. Initially the company will produce three grades of 0.95 density PE with molecular weights of 50,000, 80,000, and 100,000.

Polymeric plasticizers. Monsanto Chemical Co. has begun operation in Everett, Mass. of a newly constructed plant for large-volume production of polymeric plasticizers used to give permanent flexibility to vinyl wire coatings, coated or calendered fabrics, and similar products.

The first such plasticizer to be marketed by Monsanto, Santicizer 409, is available from the unit in fully commercial quantities after having been manufactured in interim facilities at St. Louis since its market introduction in 1959. Howard S. Bergen of St. Louis, manager of plasticizer sales for the company's Organic Chemicals Div., said that the new facility can produce other polymeric plasticizers. Two are now in the development stage, and Monsanto is sampling them with plastics compounders.

Santicizer 409 is a saturated polyester plasticizer derived from adipic acid and glycol. According to Mr. Bergen, its excellent compatibility, even under high humidity conditions, and its low volatility give it a degree of permanence seldom found even in higher-priced plasticizers. Its electrical properties make it especially suitable for wire-coating applications. In addition, it is reported to have good resistance to migration and to extraction by oils and solvents. These properties are especially important in pressure-sensitive, adhesive-backed tapes and wall coverings of vinyl plastic.

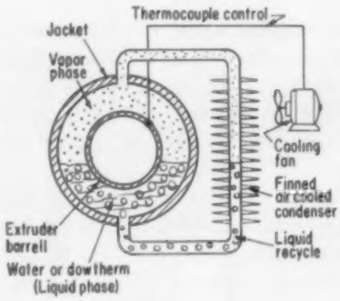
For additional and more detailed news see Section 2, starting on p. 218

NEW MACHINERY-EQUIPMENT

Specifications, claims made, and prices appearing in these pages are those of the manufacturers or sellers of the machinery and equipment described, or their agents.*

Extruders

Egan extruders with sizes ranging from 2 to 12 in. and having L/D ratios of 20:1, 24:1, and 32:1 are now available with the new air cooled Willert Temperature Control System. With this system, each individual cylinder zone is jacketed and an air-cooled reflux condenser is connected above each jacket. A schematic cross-section is shown at right illustrating the construction of each zone. Each of the zones is a completely closed system. The jackets are filled with a liquid heat-transfer medium which has a relatively flat vapor pressure vs. temperature curve. Water is used for temperatures up to 450° F. and Dowtherm A for temperatures from 350 to 700° F. As the cylinder is heated, a vapor-liquid equilibrium is created at a pressure, corresponding to the temperature of the cylinder. The liquid in the cylinder jacket does not boil as long as this pressure is maintained. If cooling is required, the thermocouple, close to the cylinder liner, activates an air blower. The vapor



in the reflux condenser condenses, reducing the jacket pressure and allowing the liquid in the jacket to boil. The condensate is recycled to the bottom of the cylinder, thus setting up a complete circulating system. Only the latent heat of vaporization is removed, and the vapor and the condensate are at about the same temperature. Thus, the control is gradual, without shock cooling but with efficient removal of excessive heat. The design of the liquid jacket cools each zone entirely. *Frank W. Egan & Co., S. Adamsville Rd., Somerville, N. J.*

Twin-screw compounder

Especially good for the extrusion of rigid PVC blends in either compounded or dry blend form, the Pasquetti Model CP-2V-20 twin-screw extruder has a nominal output capacity of 100 to 280 lb./hr., depending on the material and the shape being extruded. The two 36$^{5}/_{16}$ in.-long, 3⅞ in.-diameter, intermeshing, cemented nickel-chrome steel screws are driven by gears of the same material turning in large bushings. Two multi-row thrust bearings are fitted in the gear box to take the axial screw thrust. Sixteen screw speeds are possible by changing the driving gear systems. Screws rotate in opposing directions. The extruder has 8 heater zones—3 double zones on the cylinder, 1 zone on the plate, and 4 zones on the die —for a total of 18 kw. at 110 volts. Drive power is supplied by a 4-pole, 15/20-hp. motor. Output per unit power consumed is about 22 lb./kw. Controls are housed in a separate cabinet. *Carlo Pasquetti, Via S. Silvestro, 103, Varese, Italy.*

PASQUETTI Model CP-2V-20 twin-screw extruder has a heavy cast iron base to provide rigidity.

Press

This small air actuated molding press has been designed for use in the development laboratory or for short production runs of small, tricky molded parts, where control is an important factor. It is particularly good in molding unstable materials such as TFCE-fluorocarbon resin. Platens with heating coils, thermometer, and water cooling chamber are 4 in. square. Top platen is stationary, lower platen movable by a 3$^{11}/_{16}$ in. diameter cylinder and rubber bellows. Press operates on line pressures from 5 p.s.i. and up. Opening between platens is 7½ in., with lower platen traveling a maximum of 7½ inches. Press will take up to a 4-in.-diameter mold. *Tooling Service Co., 10307 Detroit Ave., Cleveland 2, Ohio.*

Rotary unions

These ball bearing, Rotary Unions, for axial cooling and heating fluid connections, such as on extruder screws or chill rolls, are made in two types. Type "P" is a single-inlet unit for conveying liquids or gases in or out of revolving machine components. Type "S" (syphon) has dual pipe connections where gases or liquids must enter and exit through the same unit. The new unions are made so they may be repaired in the field, eliminating the necessity to return them to the factory. A new positive seal uses a monel bellows to keep the sealing surfaces parallel and leakproof. The seal automatically adjusts for the actual pressure of the media being transferred. Ball bearings and a self-aligning design reduce strain and wear on the seal. This fitting will handle water, air, vacuum, gases, and industrial fluids at pressures up to 250 p.s.i. and steam up to 150 p.s.i. at temperatures up to 500° F. without adjustments. Stocked in pipe sizes ¼ through 3 in., with right or left hand threads. Machine threads furnished for speeds over 600 r.p.m. Flange connections are available for rotating parts. *Perfecting Service Co., 332 Atando Ave., Charlotte 6, N. C.*

(More on page 50)

* Prices are deemed to be F.O.B. sellers plants (unless otherwise stated), are for "standard" models, and are subject to change without notice. The publishers and editors of MODERN PLASTICS do not warrant and do not assume any responsibility whatsoever for the correctness of the same or otherwise.

Process cooler

The Autotherm Model 810 unit for temperature control of cooling fluids in plastics processes is ideally suited for the application which calls for consistent heat removal. It was developed primarily for accurate temperature control of water-cooled extruders. The unit can also be used on vacuum forming and other mold

AUTOTHERM Model 810 temperature control unit showing inlet and outlet connections and location of connections and remote controls.

cooling applications. A single dial sets the temperature of the cooling water circulating through the object being cooled. Then, as the heat tends to override, water is discharged on a controlled basis to maintain the specific temperature required. Piping is all brass. The unit works fully automatic at a specific temperature. Dial thermometer range is 0 to 250° F. Price is $395, F. O. B., Southport, Conn. *Distributed by the Rainville Co. Inc., 839 Stewart Ave., Garden City, N. Y.*

Injection press

Completely engineered and built in Canada for the container molding market, the Husky HM 15/19 injection press differs from most injection machines in that its operation is entirely mechanical, both for clamping and injection. Also, in line with the current trend, the machine's construction is modular: the clamping unit, injection unit, machine base, and control circuits are each entirely self-contained and detachable. A 75-ton clamp force is developed by a totally enclosed, splash-lubricated toggle system; only tie bars have grease nipples. A 1.5-hp. motor is coupled through a belt drive and electromagnetic brake-clutch to a gear drive which supplies power to the crank which actuates the toggle. Platens are 15 by 19 in., are T-slotted for Husky unit molds, and have a central daylight adjustment; maximum clamping speed is 60 dry cycles/min. The injection unit is also totally enclosed with splash lubrication and a similar drive. Rate of operation is adjustable on standard units from 7.5 to 30 dry cycles/min., optional units are supplied up to 60 cycles/min. Actual plasticating capacity is 44 lb./hr. and thin-wall containers have been produced at rates of 30 pieces/min. Maximum injection stroke of standard 1¾ in. plunger is 4½ in. and is adjustable by changing crank plates. Base is one-piece welded steel with sliding rails for injection unit and alignment rails for clamping unit. Power voltage is 220 v. 3 ph/60 cps. and control voltage is 110 volts. These timers control automatic sequence operation and the unit has two host controls and Variac nozzle control. A wide variety of optional equipment includes: variable-speed drives for injection or clamping unit; low-pressure closing device; electric eye control for fast recycling; blow-off attachment; non-standard clamping strokes from 5 to 10 in.; injection strokes from 2½ to 4½ in.; chrome-plated cylinder; proportioning heat controls; weigh-feeder. Accessories include: shut-off nozzles for pre-compression and shut-off nozzles for nylon. *Husky Mfg. & Tool Works Ltd., 200 Bentworth Ave., Toronto, Canada. Husky of America Inc., Lockport, N. Y.*

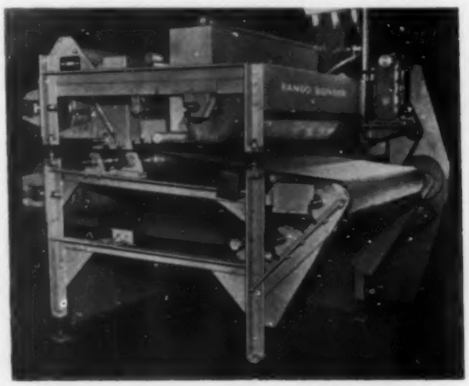
Marker

Plastic parts and containers of any size, shape, and material can be marked at average speeds up to 3100 objects/hr. on the new Markem Model 148A direct-offset machine. With no hand-rolling or -pressing, this machine automatically places imprints up to ¾ by ¾ in. on almost any surface—flat, curved, irregular, corrugated, etc. The machine can be bench-mounted for in-line marking of items carried by a conveyor or dial feed, or it can be hand fed. The 1/20-hp. motor is tripped by a foot switch or by conveyor line linkage. The unit will handle solid printing plates or Markem Masterplates, which permit quick changes of imprint data simply by inserting a new type block in the plate. A reservoir and ink plate maintain a steady flow of ink. *Markem Machine Co., Keene 55, N. H.*

Impregnator

Developed jointly by the manufacturer and the Celanese Fibers Co. (a Div. of the Celanese Corp. of America), the Rando-Bonder will rapidly saturate non-woven webs with liquids without drafting or distortion. Used with the Curlator Compact Chemical Feed System, the non-woven webs can be saturated with liquid resins. The web to be treated is continuously fed onto a bottom, horizontal, screen belt conveyor. A top screen belt, moving at the same surface speed, engages and holds the web in position. The material encased between the screen conveyors moves forward through a pre-treatment (wetting agent) zone and a liquid (resin) treatment zone in a horizontal position. The treated material then usually passes directly into a standard conveyor drying unit where the binder is set and the web is stabilized. Both top and bottom conveyor screens are continuously washed. Unused binder materials are also continuously removed and recycled. All chemically exposed equipment is made of stainless steel, and open construction is used for easy maintenance. *Curlator Corp., East Rochester, N. Y.*

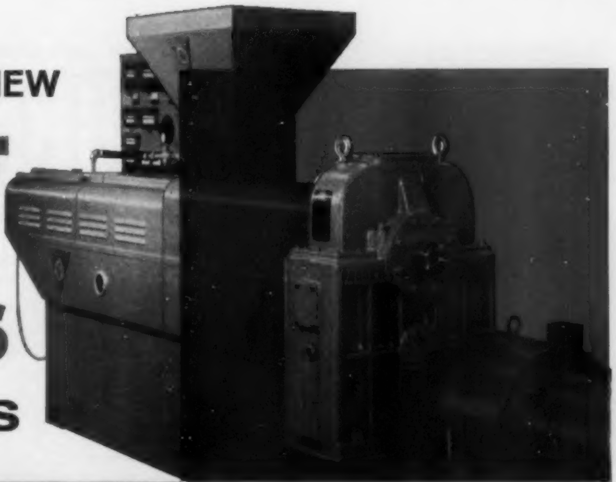
(More on page 52)

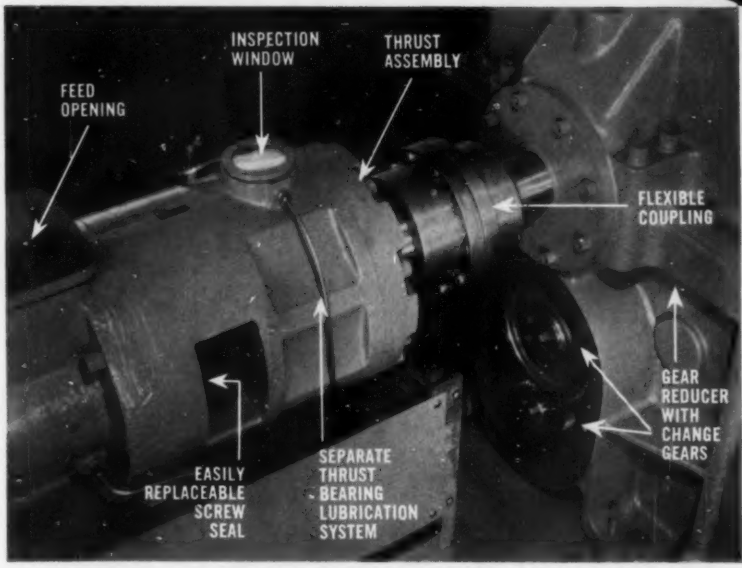


CURLATOR RANDO-BONDER showing screen conveyor belts and easily accessible parts in the open construction.

Years Ahead! The VERSATILE, NEW

PRODEX HT HIGH TORQUE EXTRUDERS with CHANGE GEARS





ONLY PRODEX HAS ALL THESE DESIGN FEATURES

- GEAR REDUCER: Vertical design for space saving and extra ruggedness. Herringbone gears thruout.
- CHANGE GEARS: For selection of the optimum reduction ratio and screw speed at any time.
- SEPARATE THRUST ASSEMBLY permits easy accessibility and maintenance. The spherical roller thrust bearing used in all machines is self aligning.
- SEPARATE THRUST HOUSING LUBRICATION SYSTEM: Oil is continuously circulated by a gear pump through a filter cartridge. Best bearing oil can be used. No compromise between gear and bearing lubricant as in other machines.
- FLEXIBLE COUPLING to absorb thermal expansion misalignment between gear reducer and extruder. Avoids any possible thrust load on gear reducer.
- FULL DIAMETER SCREW SHANK to handle heaviest torque load.
- INSPECTION WINDOW on thrust assembly housing permits visual bearing and oil feed inspection.
- EASILY REPLACEABLE SCREW SEAL to prevent leakage of dusty powders and for use of vacuum hoppers and melt feeds.
- FEED OPENING: Large rectangular opening with cooling jacket. Permits feed to flow freely.
- SELF CENTERING cylinder front support greatly reduces cylinder and screw wear.
- FULL LENGTH HEAVY MACHINE BASE
- FULLY AUTOMATIC heating and cooling controls.
- SIZES: 1¾" to 8" diam. L/D ratios 20:1, 24:1 and 30:1.
- SINGLE AND MULTIPLE STAGE VENTING
- CONTROLLED PRESSURE VALVING
- INLAY HARD-SURFACED SCREWS (not flame hardened) keep their hardness through highest extrusion temperatures.

Write for illustrated bulletin E-6.

BOTH HIGH AND LOW VISCOSITY MATERIALS CAN NOW BE EXTRUDED AT MAXIMUM H.P. EFFICIENCY AND OUTPUT

LOOK AT THESE HORSEPOWER RATINGS

EXTRUDER SIZE	HORSEPOWER RATINGS
1¾"	7½-10
2½"	20-40
3½"	40-100
4½"	60-150
6"	125-200
8"	200-400

The versatile PRODEX **HT** EXTRUDER gives you the opportunity to quickly select the optimum reduction ratio and screw speed necessary to achieve the highest possible production rate for each extrusion job.

This is now possible because the new PRODEX gear reducer with change gears is capable of transmitting as much torque as the screw can handle. All plastic materials can now be run at maximum output and horsepower efficiency of the motor drive.

Let us show you **all** the new features incorporated in the new PRODEX **HT** EXTRUDER. See it perform with your own materials in our customer service laboratory. Write or phone for appointment.

PRODEX —in design and performance ALWAYS A YEAR AHEAD

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FORDS, NEW JERSEY · Phone: HILLCREST 2-2800

IN CANADA: Barnett J. Danson & Associates, Ltd., 1912 Avenue Road, Toronto 12

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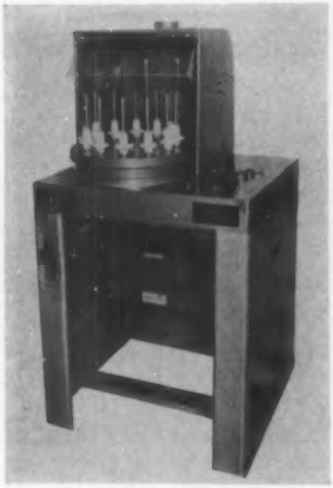
 (From page 50)



Bottle treaters

Designated Ionomatic, these electronic surface-treating machines are offered in three models and can be used for polyethylene bottles and other hollow items. Model A has eight bottle spindles, uses single discharge, and has a three-step pulley. Model B also has eight spindles but has double discharge and a four-step pulley. Model C is the same as Model B but has 12 spindles. The machine consumes about 180 w. of power and will treat up to 2000 pieces/hr., depending on the model being used and the product being treated. Unit is 28 in. sq. by 52 in. high and weighs about 110 pounds. Standard models include push-button controls and built-in vent hood. Ordinary spring wire is used for electrodes and is easily bent for treating irregular shapes. *International Eastern Co., 801 Sixth Ave., New York 1, N. Y.*

Impulse sealer

The Sentinel Impulse Sealer, Model NV-6, has been designed to provide a light, hand-operated portable sealer specifically for the sealing of unsupported materials such as polyethylene, vinyl, nylon, etc. With the Model NV-6, the sealer is brought to the job, instead of the job to the sealer, which is important in some sealing applications. The sealer may also be adapted to bench work or use in a fixed position. The unit consists of an automatic time-control cabinet with an extension cord to the sealer, permitting operation 20 ft. away from the cabinet by simply pressing the switch on the sealer. No air pressure is required for jaw pressure. The sealer contains a spring device which applies the proper minimum jaw pressure (regardless of the operator) essential to a good impulse seal. The sealer has an impulse wire in both the top and bottom jaws. It will seal to each other two layers of film up to 0.012 in. thick each, with seal lengths up to 6 inches. The device has a throat depth in excess of 2 inches. Power required is 110 v. 60 cycle at 20 amps. Model NV-8 and NV-10, with seal length of 8 and 10 in. are also available. Prices of NV-6, NV-8 and NV-10 are $290, $320, and $345, respectively. *Packaging Industries Limited Inc., 151 Pine St., Montclair, N. J.*

Blender-loader

Designated Models 500-B and 750-B, these two units, which differ only in capacity, are designed for automatic mixing and hopper-loading of two different granular plastic materials, such as virgin pellets and scrap being recycled. Model 500-B has a feed rate of 600 lb./hr. and a bin capacity of 500 lb. (based on material bulk density of 35 lb./cu. ft.) and occupies a floor space 30 in. square. Model 750-B has a feed rate of 1500 lb./hr. and a bin capacity of 1000 lb. (on the same basis as above) and occupies a floor space 38 in. square. The two materials being processed are picked up from two separate bins, blended in a dust-trapping mixing chamber, where air is separated from the mixed material, and vented through a filter. Material then drops into the machine feed hopper. Operation is fully automatic and an interval timer feeds second material to the first according to a dial setting which adjusts the mix to the proportions desired. If desired, the mixing chamber can be by-passed and the unit can be used to feed two process machines with different materials. *Thoreson-McCosh Inc., 18208 W. McNichols Rd., Detroit 19, Mich.*

. . . Machinery in brief

- Improved heat and light-resistant Dy-Dips (for use in vacuum metallizing of thermoset and thermoplastic parts) are fast tinting, have superior clarity, and excellent tank stability. *Vernon Specialties Inc., 42 River St., N. Tarrytown, N. Y.*

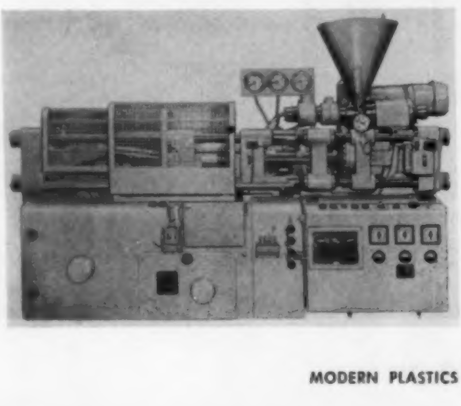
- New line of thermostatic steam traps includes high- and low-pressure types of pressure-balanced thermostatic and float-thermostatic designs. *Farris Engineering Corp., Palisades Park, N. J.*

- Efficient, controlled heat for melting or heating plastics, chemicals, and other compounds is achieved with electrically heated cylindrical tanks and pots that are manufactured by the *Sta-Warm Electric Co., Ravenna, Ohio.*

Injection machine

Designated Model BSM-40VP, this machine has a screw plasticator unit with a screw ratio of 1:22 as compared to a ratio of 1:10 generally found in similar units. The screw plasticator units are suitable for use with all thermoplastic compounds, and dry colored materials can be processed without danger of streaking. The unit was specifically designed for automatic mass production. The maximum plasticating capacity of the extruder is 26 lb./hr. and the machine dry-cycles at 10 shots/min. Maximum injection capacity is 3½ ounces. The cooler molding temperatures possible with screw pre-plastication require less injection pressure, resulting in less internal stress, and give a faster molding cycle. Material feed of the machine is 100% self-compensating by volume. *Battenfeld Corp. of America, 959 West Grace St., Chicago 13, Ill.*

BATTENFELD Model BSM-40VP 3½-oz. injection machine, showing screw preplasticator mounted "piggy back" fashion above shooting cylinder.



WORLD-WIDE PLASTICS DIGEST*

Abstracts from the world's literature relative to plastics. For complete articles, send requests direct to publishers. List of addresses is at end of this section.

Materials

Irradiated polyethylene film. R. D. Lowry and W. G. Baird Jr. Modern Packaging 33, 121-26, 226 (May 1960). Biaxially oriented polyethylene film is irradiated by electron bombardment to produce a strong, clear, glossy, heat-shrinkable material. Mechanical, chemical, and permanence properties, as well as present and potential uses for this material are discussed.

Lightly plasticized plastics. G. Grunwald. Kunststoffe 50, 381-87 (July 1960). Small quantities (10 to 15%) of plasticizer in polyvinyl chloride have the effect of increasing the hardness and brittleness. This phenomenon is explained in a number of ways. The increasing brittleness and rigidity are caused by changes in crystal structure. The same phenomenon can be produced by heating the material.

Co-ordination polymers: a review. C. N. Kenney. Chem. and Ind. 29, 880-84 (July 9, 1960). Co-ordination polymers occupy an intermediate position between organic and purely inorganic compounds. Metal ions are linked by di- or poly-functional organic components to form polymer chains. They are of interest because they may lead to polymers of high thermal stability and high mechanical strength. Polymers containing metal ions linked by chelate rings derived from organic groups show exceptional thermal stability. Their stability is a result both of the increase in the strength of the bonding arising from ring formation, and of the way in which the chelating groups pack around the central ion making reactions with other substances sterically difficult. The methods of synthesis of the co-ordination polymers are discussed.

Molding and fabricating

Insert molding with high density polyethylene. W. L. Price and W. A. Hunter. SPE J. 16, 697-700 (July 1960). The molding of metal inserts in homopolymers and copolymers of polyethylene (PE) is discussed. Stress-cracking resistance in the area around the insert is superior in 0.95-density copolymers of ethylene and butene-1 to that observed with 0.96-density ethylene homopolymers. Wall thickness of 0.125 in. or greater is recommended around inserts in high density PE. Aluminum and brass inserts appear to be preferable to steel.

Applications

Greater military use of plastics. W. E. Victor. Canadian Plastics 1960, 28-29, 51 (Aug.). As evidence of greater use of plastics in military applications, specific attention is given to the design and development of a plastics canteen for individual potable water supply. The evolution in design is illustrated from the original canteen to the improved model in current use.

When plastic cams are better. M. A. Sanders. Product Eng. 31, 44-47 (Aug. 8, 1960). Plastic cams can be molded to closer tolerances and higher uniformity than steel cams machined one at a time. Their other advantages over steel cams are resistance to corrosion, greater life expectancy because they are self-lubricating, and lower cost for lots greater than 100. Their disadvantages are higher cost for small lots and lack of temperature stability. The significant mechanical properties are given for the most suitable plastics: acetal, nylon, melamine, phenolic, and polyester compounds.

Properties

Development of cast urethane elastomers for ultimate properties. K. A. Pigott, B. F. Frye, K. R. Allen, S. Steingiser, W. C. Darr, and J. H. Saunders. J. Chem. Eng. Data 5, 391-95 (July 1960). Properties of cast urethane elastomers made from various diisocyanates, polyesters, and glycols are reported.

Mechanical properties of plastics during exposure to nuclear radiation. M. A. Mokul'skiy, Iu. S. Lazurkin, M. B. Fiveyskiy, and V. I. Kozin. Vysokomolekuliarnye Soedineniia 2, 103-118 (Jan. 1960). Experiments with plastics under conditions of continuous nuclear radiation indicate that, parallel with irreversible effects due to the cross-linking and destruction of the polymer chains, some reversible changes take place in the mechanical properties of polymers during exposure to radiation. The reversible changes include decreases in mechanical strength, ultimate forced elasticity, and creep rate. These mechanical properties are partially restored when radiation ceases. The phenomenon results from the presence of electrons, ions, excited molecules, and free radicals, which cause a temporary rupture in the chemical bonds.

Kinetics of hydrolysis of PE terephthalate films. R. C. Golike and S. W. Lasoski Jr. J. Phys. Chem. 64, 895 (July 1960). It is estimated that at moderate temperatures, below 150° C., the only appreciable degradation of polyethylene terephthalate will occur by hydrolysis of the ester linkages. It appears that the reaction takes place in the solid state. Factors such as the degree of water sorption and the rate of water diffusion must be taken into account since they will depend on the physical structure. The hydrolytic degradation of polymer films was measured by molecular weight changes. It is a second-order reaction limited by diffusion of water into the film. The theoretical equations defining the reaction are developed.

Testing

A rolling ball viscometer for technical applications. J. G. Robinson. Brit. Plastics 33, 209-11 (May 1960). The apparatus and experimental techniques for a rolling ball viscometer are described. The method is designed specifically for technical applications that do not require highly accurate measurements. Reproducibility of the method is about 5.5% compared to about 0.5% in highly precise viscometers.

Publishers' addresses

British Plastics: Iliffe & Sons Ltd., Dorset House, Stamford St., London SE1, England.

Canadian Plastics: Monetary Times Printing Co. Ltd., 341 Church St., Toronto 2, Ontario, Canada.

Chemistry and Industry: Society of Chemical Industry, 56 Victoria St., London SW1, England.

Journal of Chemical Engineering Data: American Chemical Society, 1155 Sixteenth St., N. W., Washington 6, D. C.

Journal of Physical Chemistry: American Chemical Society, 1155 Sixteenth St., N. W., Washington 6, D. C.

Kunststoffe: Karl Hanser Verlag, Leonard-Eck-Str. 7, Munich 27, Germany.

Modern Packaging: Modern Packaging Corp., 575 Madison Ave., New York 22, N. Y.

Product Engineering: McGraw-Hill Publishing Co., 330 W. 42nd St., New York 36, N. Y.

SPE Journal: Society of Plastics Engineers Inc., 65 Prospect St., Stamford, Conn.

Vysokomolekuliarnye Soedineniia: Academy of Science of U.S.S.R., Moscow, Russia.—**End**

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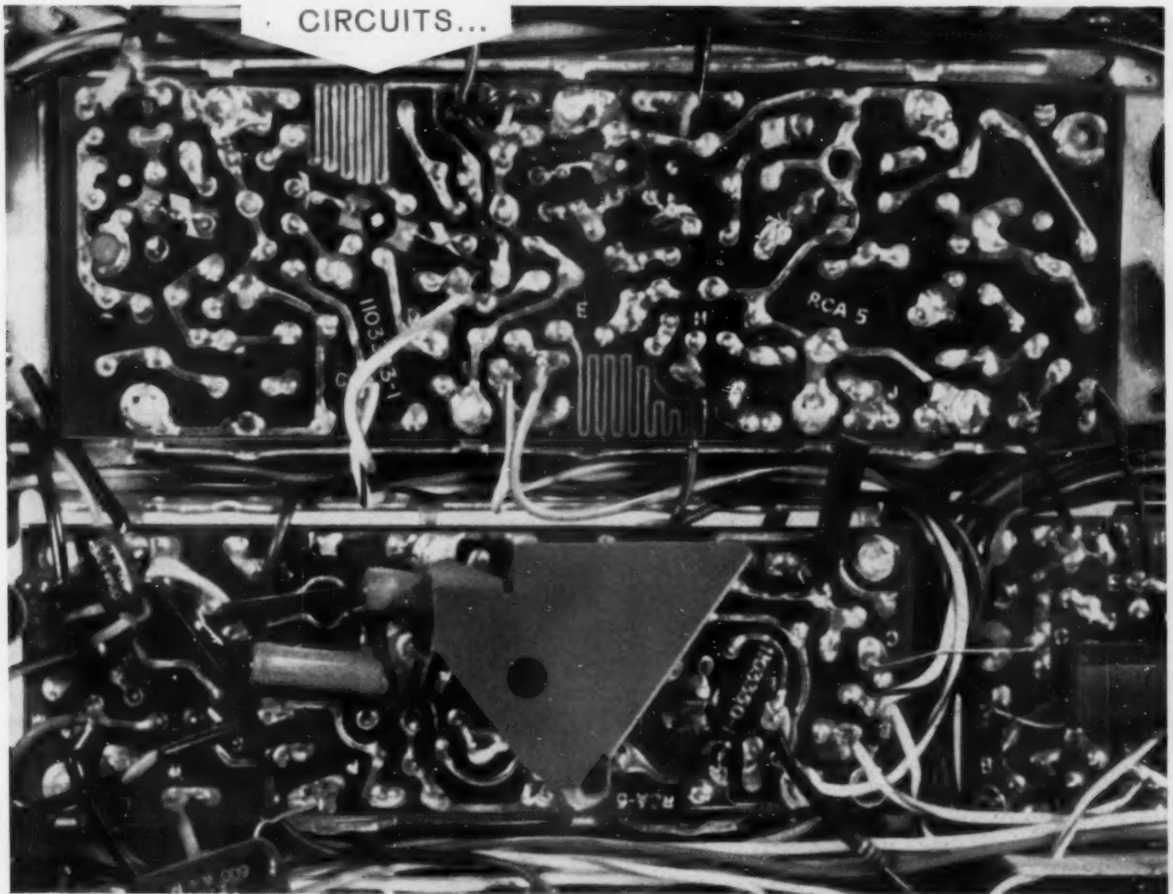

Underside of the chassis of an RCA color television receiver showing extensive use of printed circuitry on St. Regis stock.

The St. Regis Panelyte Division laminates cold punching stock with

RCI PLYOPHEN 5888

Phenolic Resin

RCI PLYOPHEN 5888 has proved exceptionally suited for laminating printed circuit stock to meet NEMA XXXPC requirements and the corresponding government grades.

St. Regis-Panelyte, for example, makes extensive use of PLYOPHEN 5888 in its XXXPC Grade 810 laminate. Mr. George E. Vybiral, chief engineer, credits this Reichhold phenolic for achieving "optimum uniformity... required for automated assembly operations . . . in printed circuitry."

St. Regis-Panelyte and other users report that PLYOPHEN 5888 excels in all of these important characteristics: 1. good cold punching properties 2. exceptional insulation resistance 3. low water absorption 4. high impact strength 5. resistance to corrosion 6. ease of machining 7. excellent performance under high soldering temperatures.

Reichhold's PLYOPHEN line also includes phenolics developed specifically for producing general purpose laminates, rolled tubing, alkali-resistant laminates and hot punching stock . . . as well as varnishes for a variety of other applications.

If you manufacture industrial laminates, RCI has the resin you need.

Creative Chemistry . . .
Your Partner in Progress

RCI **REICHHOLD**

REICHHOLD CHEMICALS, INC., RCI BUILDING, WHITE PLAINS, N. Y.

Synthetic Resins • Chemical Colors • Industrial Adhesives • Phenol • Hydrochloric Acid • Formaldehyde
Phthalic Anhydride • Maleic Anhydride • Ortho-Phenylphenol • Sodium Sulfite • Pentaerythritol
Pentachlorophenol • Sodium Pentachlorophenate • Sulfuric Acid • Methanol

U.S. PLASTICS PATENTS

Copies of these patents are available from the U. S. Patent Office, Washington, D. C., at 25¢ each.

U.S. Pats., Aug. 2, 1960

Epoxide resin. W. J. Belanger, J. E. Masters, and D. D. Hicks (to Devoe & Raynolds), 2,947,712.

Diisocyanate resins. Leclercq and R. Paquet (to Union Chimique). 2,947,-714.

Acrylate polymers. J. A. Cornell and J. L. Tucker (to H. D. Justi). 2,947,-716.

Epoxide resins. W. J. Belanger and J. E. Masters (to Devoe & Raynolds). 2,947,717.

Polymeric oxetane compositions. M. Boardman (to Hercules). 2,947,722.

Chloroethylene polymers. G. A. Clark (to Dow). 2,947,723.

Polyepoxides. H. G. Cooke Jr. and W. J. Belanger (to Devoe & Raynolds). 2,947,725-6.

Polyesters. J. K. Sullivan (to Goodyear). 2,947,729.

Vinylpentachlorophenyl sulfide polymers. E. D. Holly and W. R. Nummy (to Dow). 2,947,730.

Polymers of vinylbenzyl thiolesters of carboxylic acids. W. R. Nummy (to Dow). 2,947,731.

Trifluoroethylacrylate-acrylonitrile-acrylic ester terpolymers. B. D. Halpern and W. Karo (to Borden). 2,947,732-4.

Cyanuric acid ester polymers. L. A. Lundberg (to American Cyanamid). 2,947,736.

U.S. Pats., Aug. 9, 1960

Furfuryl alcohol resins. C. S. Price. 2,948,639.

Irradiated polypropylene. E. J. Lawton (to General Electric). 2,948,666.

Polyurethanes. R. B. Fox (to U. S. Army). 2,948,690.

Polyether polyurethanes. E. Windemuth, H. Schnell, and O. Bayer (to Mobay and Bayer). 2,948,691.

Polyvinyl chloride. F. P. Ford, G. E. Jasper, and J. F. Nelson (to Esso). 2,948,695.

Polyvinyl alcohol composition. J. A. Robertson (to Du Pont). 2,948,697.

Polyamide. A. J. Cocci (to Du Pont). 2,948,698.

Epoxy resin. C. F. Robinson (to Du Pont). 2,948,705.

Light-sensitive polymers. W. D. Schellenberg and H. Bartl (to Bayer and Mobay). 2,948,706.

Polyisocyanates. A. F. Benning (to Du Pont). 2,948,707.

Water-soluble copolymers. W. E. Walles and W. F. Toussignant (to Dow). 2,948,708.

Hydrocarbon polymers. T. Lemiszka, S. B. Mirviss, and I. Kirshenbaum (to Esso). 2,948,713.

U.S. Pats., Aug. 23, 1960

Vinylidene-aromatic aldehyde copolymers. E. C. Chapin and M. E. Murphy. 2,950,264.

Vinyl polymer composition. J. R. Caldwell and J. W. Tamblyn (to Eastman Kodak). 2,950,265.

Polycarbonates. K. B. Goldblum (to General Electric). 2,950,266.

Polypropylene. W. E. Thompson, D. M. Albright, and A. P. Stuart (to Sun). 2,950,267.

Dicyandiamide formaldehyde condensates. A. J. Francesco and S. M. Roberts (to General Aniline). 2,950,268.

Mixed polyamides. W. Reppe, H. Pohlemann, and K. Jaeckel (to Badische Anilin). 2,950,269.

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Alcoholysis of polyvinyl acetate. J. M. Snyder (to Du Pont). 2,950,271.

Encapsulation. C. E. Mercier (to Allis-Chalmers). 2,950,339.

U.S. Pats., Aug. 30, 1960

Cyclo-diene silane derivatives. H. K. Wiese, J. F. Nelson, and C. E. Morrell (to Esso). 2,951,057.

Phenolic curing catalyst. I. H. Updegraff and R. H. Hunt (to American Cyanamid). 2,951,058.

Trioxane polymers. O. H. Axtell Jr. and C. M. Clarke (to Celanese). 2,951,059.

Polyesters. H. R. Billica (to Du Pont). 2,951,060.

Polymerization. P. L. Gomory (to Phillips). 2,951,061.

Polymerization of vinyl chloride. R. D. Deanin and R. G. Dell (to Allied Chemical). 2,951,062.

Copolymers of florinated dienes. A. N. Bolstad and E. Shen Lo (to Minnesota Mining). 2,951,063.

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U.S. Pats., Sept. 6, 1960

Molding. J. M. Harrison and R. E. Smucker (to Crown Machine). 2,951,260.

Hollow plastics. O. B. Sherman (to Owens-Illinois). 2,951,261.

Polyethylene. W. L. Kesling (to Union Carbide). 2,951,821.

Polyglycidyl aromatic amines. N. H. Reinking (to Union Carbide). 2,951,-822.

Polyesters. H. Sauer (to Rutgerswerke). 2,951,823.

Polyepoxides. P. Bruin and F. H. Sinnema (to Shell). 2,951,824.

Epoxy resins. M. E. Chiddix and R. W. Wynn (to General Aniline). 2,951,829.

Terpolymer. R. H. Reinhard and J. E. Fox (to Monsanto). 2,951,831.

Fluoroelastomers. A. L. Moran (to Du Pont). 2,951,832.

U.S. Pats., Sept. 13, 1960

Irradiated polyethylene. H. F. Jordan and W. V. Smith (to U. S. Rubber). 2,952,595.

Copolymers. J. Groot and W. J. Piefers (to Shell). 2,952,636.

Aminoplast resin. S. J. Groszos and S. F. Stafiej (to American Cyanamid). 2,952,645.

Resin. R. F. Carmody (to Socony). 2,952,646.

Phenol-halohydrin resin. G. Swann and P. G. Evans (to Beck, Koller). 2,952,647-8.

Polyethylene-wax resin. M. A. McCall and H. W. Coover Jr. (to Eastman Kodak). 2,952,649.

Polyesters. A. B. Beindorff and H. D. DeWitt (to Chemstrand). 2,952,652.

Vinylidene cyanide copolymer. H. Heller (to Goodrich). 2,952,653.

Vinyl chloride polymer composition. C. E. Adams and J. P. O'Brien (to Standard Oil). 2,952,654.—**End**

In any retail display of writing instruments, the Wearever pens of David Kahn, Inc. are conspicuous standouts. They offer the shopper the irresistible combination of excellent quality, moderate price, and a wide selection of styles and colors.

From the Forticel plastic pen and pencil barrels to the Acetate transparent blister packs, Kahn depends on Celanese Plastics for product quality and package appeal.

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All good reasons why you win customer approval when you make your product of Forticel—the *better* production material. And, for the final touch of success, package in transparent Acetate!

For data on Forticel contact Celanese Polymer Company. For information on packaging materials, write Celanese Plastics Company. They are both at 744 Broad Street, Newark 2, N. J.

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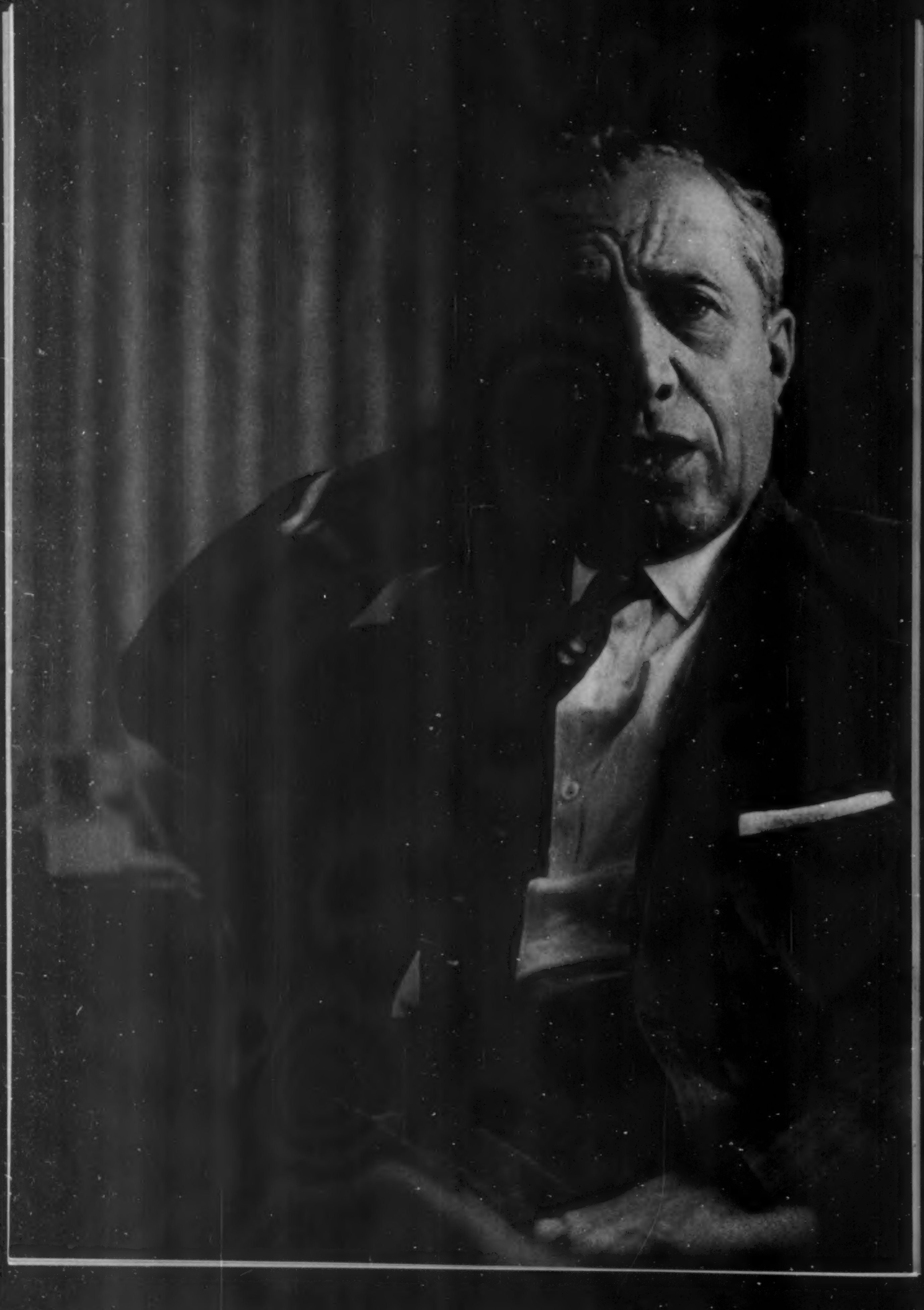
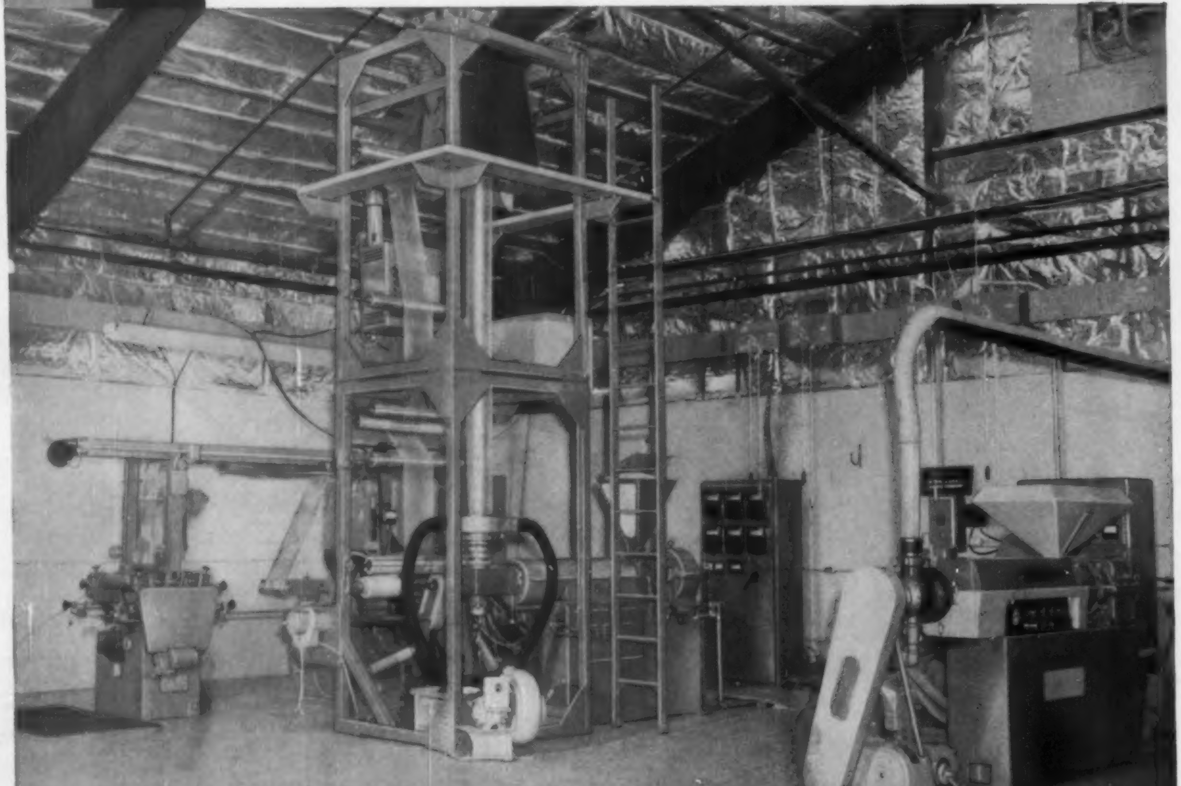
Celanese PLASTICS



the Hartig Laboratory is your laboratory for pre-production testing of extrusion processes and equipment . . .



A portion of the Hartig Laboratory showing an extruder, blown film tower, and a Rotobag bag-making and printing machine. At right is a new "T" line extruder with the new Hartig underwater pelletizer.

FOR INFORMATION ON FACILITIES & SCHEDULING OF THE HARTIG LABORATORY, CONTACT YOUR NEAREST HARTIG SALES ENGINEER:

Midwest—Chicago Area .... M. N. Levers
320 So. School St., Mt. Prospect, Ill.
Ph—Clearbrook 5-5300

Midwest—Ohio Area .... R. Guggenheim
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Metropolitan N. Y. C. .... Jim Ferrier
Box 531, Westfield, N. J.
Ph—Adams 2-9390

Canada .... Ron Keeling
1669 Eglinton Ave. W., Toronto 10
Ph—RU 1-5627

Western and Southern Area .... Contact Home Office
Box 531, Westfield, N. J.
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M-R

HARTIG EXTRUDERS

WALDRON-HARTIG

Division of Midland-Ross Corporation
P. O. Box 531, Westfield, N. J.

Ask for Bulletin FL-1 which describes our laboratory facilities.

HE-660

U.S.I. POLYETHYLENE NEWS

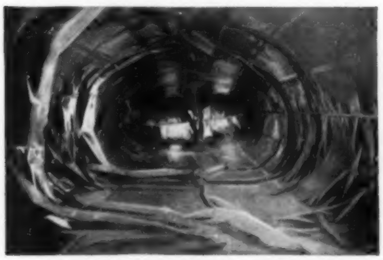
A series of advertisements for plastics and packaging executives by the makers of PETROTHENE* polyethylene resins

Disposable food-grade polyethylene liners are being used within large collapsible containers to haul edible liquids—milk, fruit juices, molasses and vegetable oils. The containers, recently introduced by a California company, can be carried on any van or flat-bed trailer, including refrigerated vans. They come in 22-, 30-, or 34-foot sizes, having capacities of 2,750, 4,000 and 4,600 gallons, respectively.

Following delivery, the disposable polyethylene liner is removed and the container rolled into a compact package, freeing the vehicle for a return trip with dry freight. To use the container again, it is unrolled on floor of truck and inflated. A sanitary poly liner is then easily spread within the container and also inflated—ready for another load.

Van-Tank is first unrolled on floor of trailer, inflated with low pressure air.

Sanitary plastic liner is quickly spread, with no contact with interior of liner.



Liner itself is then inflated, and Van-Tank is ready to receive its load.

Silver polish in a polyethylene tube stays creamy, won't dry out or cake up, and is more convenient to use. The exact amount needed can be dispensed right where it's wanted. And, when the squeeze is relaxed, excess is drawn back by the tube. New tube is printed in blue and red on white background, has a stand-on cap.

U. S. I. Introduces Two New PETROTHENE Resins For Injection Molding

Top Quality Polyethylene Resins Sell for New Low Price of 26¢ A Pound

U.S.I. has developed two new polyethylene resins tailored exclusively to the needs of injection molders producing toys, novelties and housewares. Called PETROTHENE 117 and PETROTHENE 213, they can be obtained from U.S.I. at 26¢ a pound—a record low price for top quality polyethylene resins.

New PETROTHENE resins are tailored exclusively for injection molded housewares, toys, and novelties.

PETROTHENE 117 (density 0.917 to 0.920, melt index 7.0 to 10.0) provides good appearance, extreme toughness and high gloss. Items molded from it can be expected to have low to medium stiffness.

PETROTHENE 213 (density 0.921 to 0.925, melt index 7.0 to 10.0) produces moldings of excellent appearance, good toughness and *very* high gloss. End products obtained are characterized by medium to high stiffness.

Processing Properties

PETROTHENE 117 and 213 are high-flow polyethylenes, so permit short injection molding cycles. Thus, economical production rates are possible. Molders of colored items will appreciate the ease of pigmentation offered by both new resins. They combine readily with most pigments by either dry blending or homogenization.

Optimum molding conditions will vary with equipment used and end-use requirements; these should be determined in each application. Technical assistance in determining proper conditions for specific applications is available on request from U.S.I. Technical Service Engineers. Or, for additional technical data on PETROTHENE 117 or 213 write Technical Literature Department, U.S.I., 99 Park Avenue, New York 16, N. Y.

Booklet Details Uses For Powdered Polyethylene

U.S.I. has published an 8-page booklet which explains in detail how U.S.I.'s finely divided or powdered polyethylene, introduced under the trade name "MICROTHENE", is used. Applications covered—many of which are not feasible with conventional polyethylene—include metal, textile, and glass; large moldings; and miscellaneous uses such as rubber additive, wax additive, and anti-tack agent. Data are also given on the sizes and grades of MICROTHENE polyethylene resins available. Copies may be obtained by writing to Technical Literature Department, U.S. Industrial Chemicals Co., 99 Park Avenue, New York 16, N. Y.

IF YOU WOULD LIKE further information on any developments reported in U.S.I. Polyethylene News, U.S.I. will be glad to send you the names of the manufacturers. U.S.I. also invites you to send information on your new developments for possible inclusion in the News.

Address the Editor,
U.S.I. Polyethylene News, U.S. Industrial Chemicals Co., 99 Park Avenue, New York 16, New York.

Flower Pots Made from Coconut Husk Fibers with Aid of Polyethylene

In Puerto Rico, polyethylene film is being used as a mold liner in the production of plant pots from "Coir" fibers—the commercial name for the product obtained by defibering the husk of the coconut. These fibers—which are heavily lignified—yield potash and phosphoric acid on decomposition, so offer considerable value as fertilizer. Urea formaldehyde serves as a binder.

The developer of this process reports it has been in successful use for two years, credits polyethylene film with making it possible. Illustration shows how he lines mold cavity and punch with polyethylene.

Punch, mold cavity, and finished plant pot made of coconut fiber with help of polyethylene film.

U.S.I. POLYETHYLENE PROCESSING TIPS

Series V, No. 6

ANNEALING CHAMBER IMPROVES OPTICAL PROPERTIES OF POLYETHYLENE FILM

Clarity and gloss of blown polyethylene film are substantially improved by enclosing the blown tubing with an annealing chamber, or "chimney", located between the extruder die and air ring. (See schematic below.) The new technique has little significant effect on the strength characteristics of the film. It does, however, require closer control to maintain bubble stability.

The chimney, a development of U.S.I.'s Polymer Service Laboratory, can be made of inexpensive materials such as cardboard, glass or insulated metal. It can be constructed in two sections or hinged, to eliminate threading the "bubble" through the chamber.

Although chamber diameter is not critical, best results are obtained with a chamber diameter 2" to 3" larger than the die diameter.

Importance of Retention Time

The degree of improvement in optical properties depends on retention time – the time it takes extruded film to travel from die lips to top of the chamber. This is a function of haul-off speed and chimney height.

A retention time of 2 seconds gives maximum optical improvement but requires a chamber height of 30" at haul-off speeds of 75 ft/min. This is not feasible from a production standpoint as serious blocking of warm film occurs and gauge is difficult to control.

With respect to production, a retention time of one second seems optimum. This gives significant optical improvement at more realistic chamber heights – 10"-14" – and haul-off rates – 50-70 ft/min.

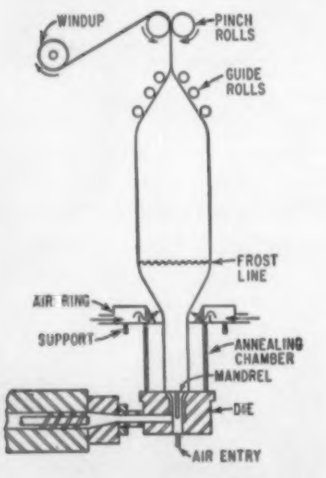
Effect on Film Properties

Test results given in the accompanying table show that the annealing chamber improves the optical properties of film made from some polyethylene resins more than others. In both transmittance and gloss, low-density resins are improved more than higher-density resins; and higher-melt-index resins more than lower-melt-index resins.

An increase in blocking and reduction in slip may occur in some cases due to less time available for cooling. This can usually be corrected by increasing the distance between the die and the nip rolls, or by use of anti-block agents and higher slip formulations.

Technical Help and Data Available

U.S.I. engineers are continuing work on the annealing chamber study. They will be glad to consider your particular operation and help in adapting the method to your needs. You are also invited to write for a new paper describing the annealing chamber in greater detail. Address Technical Literature Department, U.S. Industrial Chemicals Co., 99 Park Ave., New York 16, N. Y.



Two-section

Hinged

How Annealing Affects Optical and Strength Properties of Film from PETROTHENE® Polyethylene Resins

PETROTHENE Resin	239-27 (5/MI; 0.929 density)		205 (3/MI; 0.924 density)		200-28 (3/MI; 0.916 density)		201 (5/MI; 0.916 density)	
Retention Time, Sec.	0	1	0	1	0	1	0	1
Haze, %	7.9	7.6	7.9	6.8	10.5	6.8	9.5	5.1
Gloss, %	10.2	11.8	10.9	12.3	7.5	9.3	6.9	10.4
Transmittance, %	68	72	54	61	38	57	39	70
Impact Strength Sand Bag, ft.	1	1.5	1	4	6	7.5	>9	>9
Dart Drop, g.	215	80	–	–	175	85	280	255
Elmen. Tear M.D.	175	140	165	60	65	40	60	45
T.D.	170	105	145	100	75	75	45	65

U.S.I. INDUSTRIAL CHEMICALS CO.
Division of National Distillers and Chemical Corp.
99 Park Ave., New York 16, N. Y.
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Home for Christmas

Season's Greetings

DAVIS - STANDARD

DIVISION OF FRANKLIN RESEARCH AND DEVELOPMENT CORPORATION

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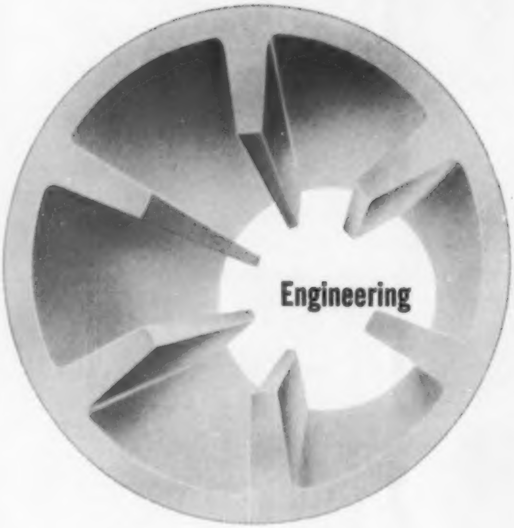

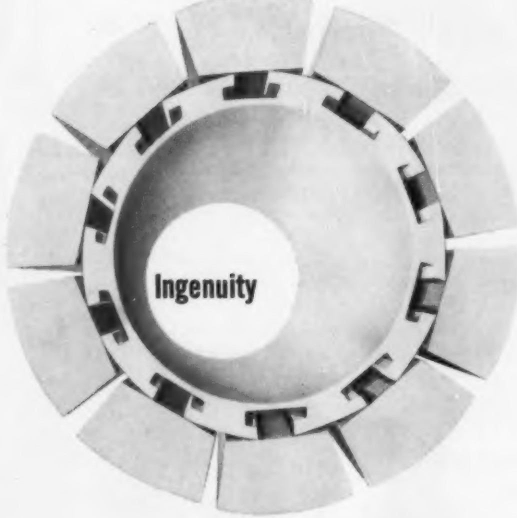

Lembo Aluminum

IDLER ROLLS

Lembo has engineered a stronger and lighter Idler Roll . . . stronger because of unique wall and fin design . . . lighter because it's aluminum. As the roll turns, heat is evenly distributed and dissipated. This positively eliminates any chance of distortion.

SLAT EXPANDERS

Put this Lembo Slat Expander to test under most severe conditions, including temperatures up to 500°. You'll get no wrinkles or creases in your films or textiles. Where friction is not desired, it may also be separately driven without modification.

Available in a variety of lengths for
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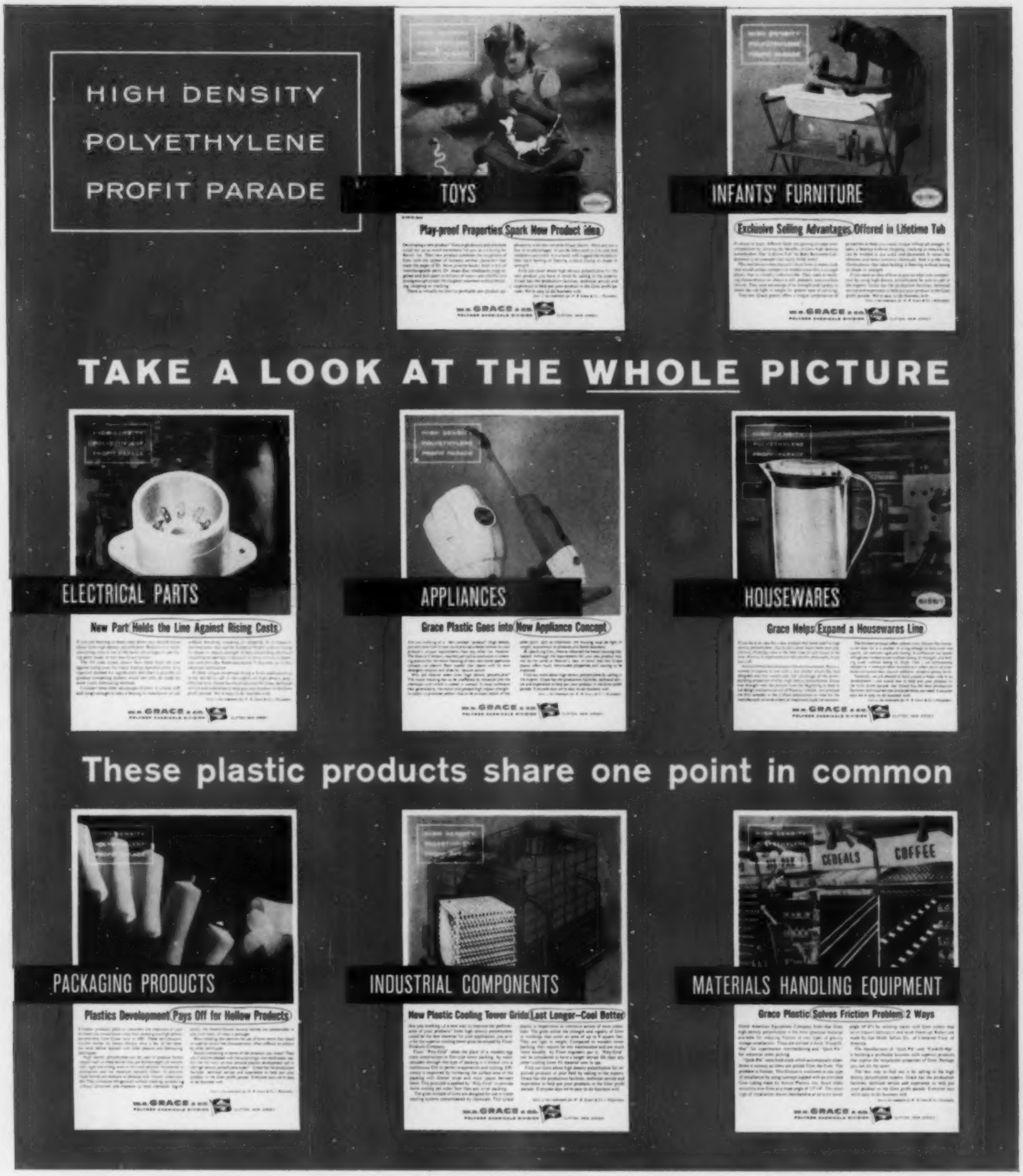
There is only one Lembo Machine! Be cautious of "Lembo-type" imitations.



These products offer concrete evidence of manufacturers who have realized the profit-making opportunities to be found in high density polyethylene from W. R. Grace & Co. New products . . . better products . . . products that last longer . . . cost less to make . . . products with greater sales appeal . . . products that complete a product line—all can start with Grex High Density Polyethylene. If you have an application for high density polyethylene—or think you have—it will pay you to call Grace.

Grex is the trademark for W. R. Grace & Co.'s Polyolefins.

W.R. GRACE & CO.
POLYMER CHEMICALS DIVISION
CLIFTON, NEW JERSEY

WELDING HELMETS SERVING TRAYS MODERN CHAIRS MERRY-GO-ROUND HORSES

So many good things serve you better because of fiber glass

(Johns-Manville Fiber Glass, that is!)

Sturdy, weather-resistant playtime equipment . . . rust-proof gardening gadgets . . . all kinds of protective headgear. There are thousands of intriguing, lightweight plastic products that serve you better and last longer because they are reinforced with Johns-Manville fiber glass. It has opened new worlds of useful products that are both easy to maintain and pleasing in design.

BOWS & ARROWS FIRE HELMETS GARDEN HOSE REELS HAMMER HANDLES TOTE BOXES

only 9720 lets vinyl makers DO BOTH

If you find yourself in the "cut cost — keep quality" squeeze (and who isn't these days), you can expect real help from Plastolein 9720. This is because 9720 contributes the quality characteristics of a polymeric, yet is the *lowest* cost polymeric available today.

9720 offers excellent permanence in terms of low volatility, low migration, and resistance to "wipe off," heat and ultraviolet light—which make it an ideal primary plasticizer for many formulations. And its ability to match the low temperature properties of many monomerics vastly widens the range of its uses.

Also—9720—which processes like most monomerics—is fluid enough to be handled economically in bulk.

All this explains why time-tested 9720 is the largest selling polymeric today. Why not let this talented low-cost performer take you out of the "cut cost—keep quality" squeeze. For complete details write Dept.F-12 for booklet—"Plastolein Plasticizers."

Emery PLASTOLEIN® PLASTICIZERS

Organic Chemicals Division, Emery Industries, Inc.
Carew Tower, Cincinnati 2, Ohio • Vopcolene Div., Los Angeles
Emery Industries (Canada) Ltd., London, Ontario
Export Division, Cincinnati

December 1960, Volume 38, Number 4

MODERN PLASTICS

SPACE AGE film balloon typifies aggressive growth of plastics films into new industrial markets. Model shown at right is designed to be inflated in space, where the two halves will separate, leaving the metallized lower half to collect solar energy needed to run delicate satellite machinery.

Photo, Goodyear Tire & Rubber Co.

You can do wonders with film

✓ *cut product costs*
✓ *improve product performance*
✓ *create new concepts in product design*

Visualize a material that has an average tensile strength of 20,000 p.s.i., and yet is twistable, wrappable, foldable, and bendable . . .

. . . visualize a material with a dissipation factor of 0.12 at 1 mc. frequency and flexible enough to be tied into a knot, thin enough to slip into a slot for which paper was too thick . . .

. . . visualize a material with a burst strength of 40 to 75 (Mullen) p.s.i. that can be inflated to almost any size or shape . . .

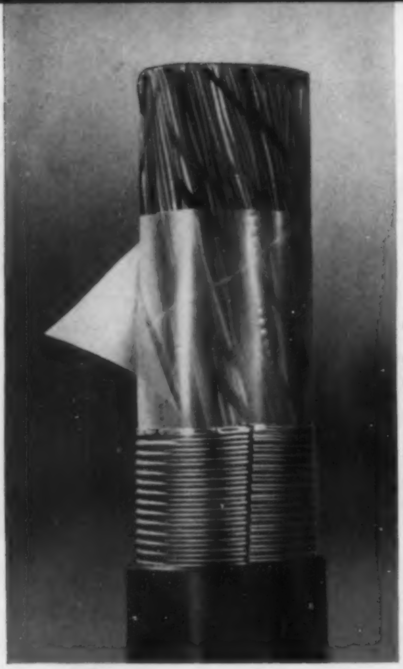
. . . visualize a material that can resist temperature extremes from —60 to 150° C., yet resilient enough to be rotated continuously around a series of rollers.

If you can orient your thinking in this direction, then you are in the wonderful world of plastics industrial films, where inflatable buildings can be erected in seconds . . . where electroluminescent lighting panels can bend around corners . . . where flexible printed circircuits can solve the many complexities of modern electronics.

And engineering (non-packaging) film is big. Its use has doubled in the past five years and by 1965 is expected to account, together with fabric replacement applications, for 600 million lb. of resin annually.

For those designers who are first beginning to understand the effectiveness of the plastics films, for those designers who are yet to be

IN ELECTRIC MOTOR, polyester film won the nod as choice slot insulation material. Its inherent properties—high dielectric strength and abrasion and moisture resistance in thin gages—have made electrical designers pick it for a host of applications.



Photos, E. I. du Pont de Nemours & Co., Inc.

INSULATING properties of thin-gage polyester film prevent surges between aluminum cable shield and insulated wiring. At the same time, the film's strength prevents shielding from chafing as well as puncturing coated insulation of the wires.

initiated, this review summarizes what has already been done with plastics films—and what is yet to come!

Radical new concepts

On the horizon, for example, is an extended use of plastics films to solve the complexities of tomorrow's "space travel" and "space research." At a recent Air Force conference, Dr. Carl E. Snyder of The Goodyear Tire & Rubber Co. reported that plastics films sent into space may actually become stronger than on earth when exposed to environmental extremes that can weaken or destroy metal. His reasoning behind the statement is threefold: 1) polymers do not boil away as easily as metals under the influence of the near-complete vacuum of space; 2) those molecules which do boil away are the molecular system's "weak sisters" whose loss frequently leaves behind an enhanced polymer; and 3) gases such as oxygen tend to fuse to the ends of molecular chains broken by ultra-violet bombardment, thus making the break permanent, or the broken chains can recombine to form a strong, and sometimes even stronger, polymer structure. Polyester and polypropylene film were cited by Dr. Snyder as most likely candidates for space use.

On a more practical level, two of the more radical concepts involving plastics films are already with us—and showing signs of strongly influencing tomorrow's industrial design. These two concepts are: 1) flexible printed circuits and 2) electroluminescent light panels.

The flexible printed circuit is a simple sandwich in which the etched metal circuit (generally copper) is bonded permanently between two layers of plastic film. For those applications where high temperatures and corrosive atmospheres are involved (*e.g.*, in missiles), the fluorocarbon films (Du Pont's FEP-fluorocarbon and Minnesota Mining & Mfg. Co.'s Kel-F fluorocarbon) can be put to use. For those applications where temperatures do not exceed 125° C. and environmental conditions are not as rigid, polyethylene, propylene, vinyl, and polyester films have been successfully used. Sanders Assocs. Inc., Nashua, N. H., and International Resistance Co., Philadelphia, Pa., are reportedly working on producing such flexible circuits to meet design demands in complex electronic systems and long-length wiring that can not now be serviced by rigid circuits.

Electroluminescence, the most recently discovered means of converting electricity into light, has only now started to get off the ground—and plastics films are already playing a major role. Volume-wise, it could be a big market for the films. Estimated size of the EL market this year is from $4 to $6 million; for 1965, experts are predicting a $200 million market.

Electroluminescence is based on the use of

special phosphors that can convert electrical energy into light. Unlike incandescent or fluorescent products, no filaments or vapors are involved. Three systems are currently in use. The first, used by Sylvania Lighting Products, is made up of a thin ceramic plate coated with phosphors and protected by a clear layer of 5-mil rigid vinyl (from Union Carbide). The vinyl film shields the phosphor layer from breakage and abrasion while providing clarity for the EL glow to pass through. In a second reported system, the phosphors are suspended in cast vinyl film and laminated to a rigid glass backing plate.

But it is in the third system—a truly *flexible* EL panel—that plastics films really come into play. As developed by General Electric and used by them in a new night light, the panel is created by first suspending the phosphors in cast Cyanocel film (available from American Cyanamid Co.)

The cellulose film is then sandwiched between a transparent face of glass cloth and a backing of aluminum foil. The entire assembly is finally enclosed in an envelope of polychlorotrifluroethylene film (based on 3M's Kel-F resin and supplied by Visking Co.) that serves as a moisture vapor barrier.

The EL night light provides 4.5 footlamberts. It is a $\frac{1}{10}$-watt unit, has a rated life of 15,000 hr., and operates for many months on just a 1¢ current cost.

Immediate markets for EL: night lights, exit signs, instrument lighting. Potential markets: wall murals, table tops, decorative columns. And eventually (experts say within 5 to 10 years): complete area lighting!

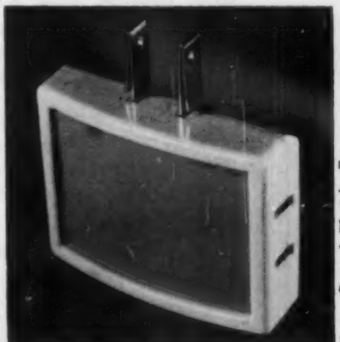
Film for electrical applications

The most impressive demonstrations of the new technology of "plastics films as engineering materials" has taken place in the electrical and electronic fields where demand for added performance, reduced costs, and compactness in design is most insistent.

Take the construction of a telephone exchange area cable as a typical example. The build-up begins by convolutely wrapping a core of wires in 3-mil polyester film (Mylar film from Du Pont); over this is placed an aluminum shield; over the shield, a wrapping of 2-mil acetate film (from Celanese); nylon filaments bind the assembly tightly together; and polyethylene is then extruded over the entire unit. And what is the function of the plastics films? Together, they offer a high degree of heat insulation that prevents softening and sticking of the wire insulation during extrusion of the polyethylene jacket. Individually, the polyester film provides a barrier for lightning surges between the cable shield and the insulated conductors, the acetate film evens out the contours of the aluminum shield to prevent it from cutting into the polyethylene jacket.

In the variety of plastics films available, the electrical engineer finds he has a sufficient balance of properties to meet most any problem.

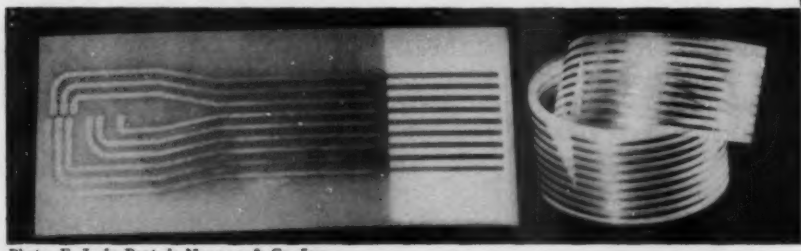
Polyethylene and polypropylene film are al-



FLEXIBLE electroluminescent panels, based on phosphors suspended in cyanoethylated cellulose film, are put to use in a unique night light. Kel-F film also is used as a moisture barrier in similar assemblies.

Photo, General Electric Co.

FLUOROCARBON FILM'S excellent electrical properties and high-temperature resistance are put to work in flexible printed circuit (left) and printed cable (right). Top layer of film is stripped off the end of circuit (lighter area) for attachment of connectors.



Photo, E. I. du Pont de Nemours & Co. Inc.

Photo, E. I. du Pont de Nemours & Co. Inc.

AS TOUGH, weatherable surfacing material, pigmented polyvinyl fluoride film is applied to underside of steel roofing panels to eliminate the costly as well as time-consuming task of painting the factory ceiling.

ready going into specialized electrical applications (cable tape, capacitors, phase separators). Acetate film is widely used in the electrical industry for its good mechanical properties, its high dielectric strength (at 25° C., and 0% RH, 2800 to 3600 v./mil; at 50% RH, 2300 to 3000; at 95% RH, 1300 to 1800), and its resistance to electrochemical corrosion. Applications include: interleaving or layer insulation for solenoid coils, transformer windings, and relay coils; tubular condenser dielectric film; magnet wire wrappers; and motor slot insulation and slot wedges.

Among the newer films, it has been the polyesters (notably Du Pont's Mylar) that have made the greatest impact. Its electrical properties are outstanding: dielectric constant at 25° C., 60 cycles, is 3.2; at 1 kc, 3.1; at 1 mc, 3.0. Power factor at 25° C., 60 cycles, is 0.003; at 1 kc, 0.005, at 1 mc, 0.016. Dielectric strength at 25° C., 60 cycles, is 4000 volts/mil; volume resistivity at 25° C. is 1×10^{19} ohm-cm.

Here are the three major areas of use for the polyester films, as reported by Du Pont.

Motors: The final link in a series of technical innovations that led to widespread redesign of small electric motors was the development of polyester film for insulation systems. In slot liners, for example, the film's high physical and dielectric strength and its temperature properties allowed manufacturers to reduce slot dimensions by about ½, replacing 15-mil paper with 7½-mil polyester film. In phase insulation, as another example, replacement of paper with thinner-gage polyester saves space and provides improved resistance to coil-to-coil failure.

Capacitors: The trend toward miniaturization owes much of its progress to the high dielectric properties of polyester film. In round numbers, the ratio of gage for equal dielectric capabilities between film and paper is about one to two! And within its temperature range (up to 130° C.), the film provides a higher level of insulation resistance than do conventional materials. Metallized polyester film also stands out as a possible contender for traditional film-foil and paper-foil capacitor constructions.

Wire and cable: As a replacement for 12-mil rubber-filled cotton tape used to protect wire insulation from mechanical abuse, manufacturers are currently using a 1-mil-thick tape of polyester film. On a square yard basis, the cost of the plastic film is about one third that of the rubber-filled material! In addition, its strength allows increased production speeds, while over-all wire diameter is reduced, with corresponding savings in jacketing materials.

Polyester film is also used in electrostatic shielding, where laminations of polyester and foil replace heavy metal braids; primary insulation where the film's high dielectric strength and low moisture absorption (less than 0.4% after 24-hr. immersion) provides low-voltage wire of minimum insulation build-up with maximum reliability; and as an insulation guard to protect conductor insulation from puncturing or chafing by metal braid.

And now for the new films!

In the polyester field, mention should be made first of Acme Backing Corp.'s **Terafilm polyester film** (based on Eastman Chemical's resin) which has just appeared on the market. It is recommended for use in capacitors (where its characteristics indicate it may possibly be able to be used uncased), in cable and wire, in coils, in slot liners, and in tapes. Its dielectric constant at 1 kc., 25° C., is 3.15; at 75° C., 3.11; at 100° C., 3.12; at 125° C., 3.19. Its dissipation factor, at 1 kc., 25° C., is 0.0043; at 75° C., 0.0022; at 100° C., 0.0022; and at 125° C., 0.0072. Dielectric strength vs. time for ½-mil film at 60 cycles and 25° C., is 4800 volts/mil for 10 sec.; 2000 v./mil for 10^3 sec.; and 1100 volts/mil for 10^6 seconds.

But outside of the polyester film field, there

are even newer plastics waiting to be heard from. And to the same extent that polyester films have supplemented more conventional films and opened new electrical applications, some of these newer materials may supplement the polyesters and further expand potentials.

Fluorocarbons: Historically, the first major advance in capacitor construction—capacitors that could operate in the 200° C. range with adequate levels of insulation resistance and dielectric strength—came with films of TFE-fluorocarbon resins (Teflon film from Du Pont). More recently, FEP-fluorocarbon films (Teflon film from Du Pont), commercialized early in 1960, have been made available that offer lower price, freedom from pinholes, ability to operate in the 130 to 250° C. range, and heat sealability. The material shows promise as a moisture- and solvent-proof thin-wall jacketing, as thin-wall primary insulation, and in formed coil applications where extreme temperatures or unusual chemical atmospheres prevail. The dielectric strength of 1-mil film is 3200 volts/mil; in 15-mil film, it is 1500 volts/mil. Dielectric constant at 23° C., 30 cps. to 3 mc. and at —40 to 240° C., 1000 cps., is: 2.2; dissipation factor under both similar conditions is 0.0002. Volume resistivity is $> 10^{17}$ ohm-cm.

Minnesota Mining & Mfg.'s polytrifluorochloroethylene film (Kel-F) is similarly expected to find outlets in electrical markets. The unplasticized film has a dielectric constant of 2.3, dissipation factor of 0.004, volume resistivity of 1×10^{18}, and dielectric strength of 2500 volts/mil for a 1-mil film. For plasticized Kel-F, the dielectric constant is 2.4; dissipation factor, 0.013; volume resistivity, 1×10^{15}.

Polyvinyl fluoride film (Teslar by Du Pont) is currently being evaluated as curing tapes for rubber-insulated cable, pigmented tapes for conductor color coding, and weatherable jacketing. Its dielectric constant at 72° F., 1 kc, is 6.8 (8.5 when the film is pigmented). Dissipation factor at 72° F., 60 cycles, is 0.006; at 1 kc, it is 0.013. Volume resistivity at 72° F. is 3×10^{13} ohm-cm., at 270° F., it is 1×10^{10}. Dielectric strength, 60 cps., kilovolts/mil is 4.1 for 1-mil film, 2.3 for 3-mil film.

The most recent of plastics films to go after the electrical market is a very new chemically modified (cyanoethylated) cellulose known as Cyanocel and marketed by American Cyanamid Co. Two of the film's striking electrical properties stand out: its high dielectric strength (13 at 100 cycles at 25° C., 12.8 at 1 kc, 11.7 at 110 kc, and 10 at 1 mc.) and its low dissipation factor (less than 0.02 at 25° C. at 100 cycles, 1 kc, and 10 kc, 0.04 at 100 kc, and 0.12 at 1 mc. at 25° C.). It can be cast into film from $\frac{1}{10}$ to 10 mils thick. Its first commercial application: a flexible electroluminescent lighting panel (described above). Future possibilities: microminiaturization of electronic components such as capacitors and transformers.

Film as a structural element

Striking evidence of the strength of plastic film is the recent emphasis on inflatable film structures, so-called air-houses, and bubble buildings—primarily of polyester or PE film. The trend started in 1959 and has progressed steadily since. This year, a number of high-altitude balloons fabricated of either polyethylene or polyester film were sent up by the military—and on Aug. 12, plastic film had its biggest boost when the (To page 173)

Photo, Koppers Co. Inc.

IMPERMEABILITY of PE film to gases has opened such new industrial uses as seals over metal stoppings in coal mines. Seals direct vital air currents toward working faces.

Shells and bullets of plastics—

here's why

- **Shotgun shells that perform better**
- **Training bullets that cost less**
- **Cartridges that bring safety to new sport . . .**

. . . these are among the reasons for, and result of, use of new plastics materials and processing techniques

Advances in resin technology and processing methods are broadening plastics' market base in the field of small-arms ammunition far beyond their initial penetration as special-pistol bullet jackets (see "Polyethylene cartridges," MPl, p. 95, Dec. 1958). At the moment, the primary target areas are shotgun shells and pistol training ammunition; and the most important materials are high-density polyethylene and nylon. But broader markets and more diversified material usage are being seriously discussed in many quarters.

Better shell bodies

The routes along which plastics are traveling to success in this application are the twin avenues of product improvement as well as lower cost.

Traveling along the first route is Remington Arms Co. Inc., Bridgeport, Conn. In designing its premium grade SP (S for steel, P for polyethylene) shells with a high-density polyethylene body and steel head, the company did increase the cost of the product; but in doing so, it came up with a shell that would satisfy the demands of the all-weather hunter for ammunition that is weatherproof, will not swell in rain, sleet, or snow, and one that is dimensionally and ballistically stable. Superiority of product in this instance decisively outweighed considerations of cost. The new shells are available in 12-gauge long-range loads in 2-, 4-, 6-, and 7½-shot size.

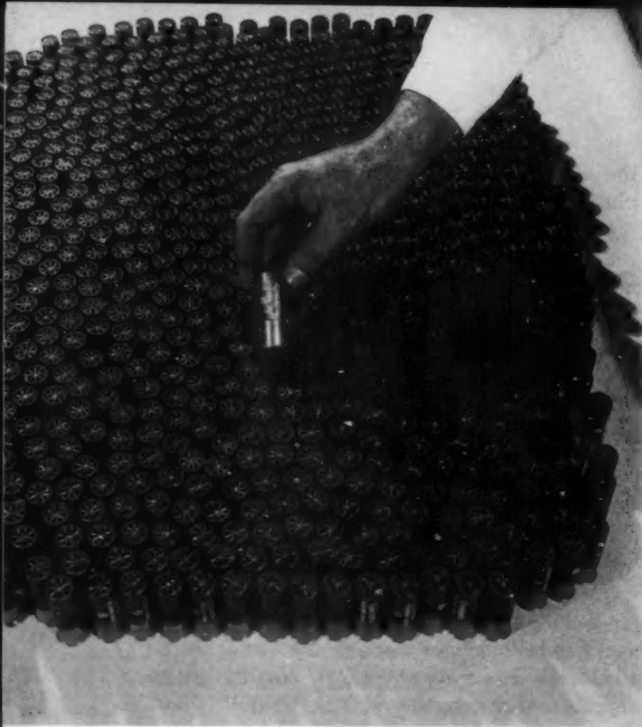
The significance of the Remington Arms development, however, does not lie simply in the production of better shotgun shell. Of equal importance is the fact that new production techniques were developed to make it.

The shell bodies are extruded in a one-piece, corrugated seamless construction. According to Remington Arms, linear polyethylene, as ordinarily processed, would not be strong enough for the shell body but would result in body cut-offs and splits. To overcome this strength problem, Remington uses what it terms a biaxial orientation process, which it claims makes the material four to five times stronger. Details on the process, on which the company states patents are pending, are not available for publication. However, it should not be confused with the Hoechst technique of biaxially stretching high-density polyethylene pipe ("Why biaxially oriented pipe?", MPl, Nov. 1960, p. 111). This process involves the pulling and blowing of the extrudate, and results in a pipe with double the burst strength of unoriented pipe. How the Remington process differs from this method is not known.

While Remington is commercial with these shells, other ammunition makers are currently doing development work with injection molded versions; however, this effort has not progressed very far at this writing.

The market for PE shotgun shells is large. While no precise figures can be cited, millions of duck hunters and upland shooters can use

INDICATION OF QUALITY: Remington Arms SP shells went through cycle in a home washer; looked perfect, chambered and fired like new.



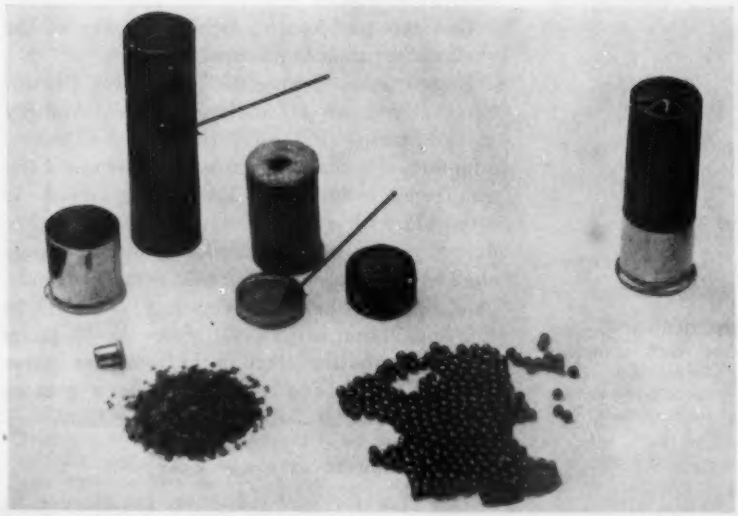
SHOTGUN SHELLS by Remington Arms are first to use a high-density polyethylene body.

them. Approximately 5 lb. of polyethylene resin are used for each 1000 Remington Arms shell bodies.

PE for shell wads

A related development is the use of low-density polyethylene for over-the-powder wads. Remington has been using them in its factory-loaded ammunition and is now offering them to reloaders of shotgun shells. The Alcan Co. Inc., Alton, Ill., also injection molds wads for its shells and for reloaders. Of Eastman Chemical's Tenite, the Alcan wad (Air-Wedge) successfully replaces paper units. Here again, property improvement was the prime consideration, cost secondary (see photos below).

Because of the economies made possible by



COMPONENTS of Remington shells are shown with assembled shell. Biaxially oriented polyethylene body as well as the low-density wad are indicated by colored arrows.

MOLDED PE WADS used in standard paperboard shells incorporate unique design features for improved action. Colored area in sketch of shell (right) made by The Alcan Co. indicates location and correct position of wad in assembled unit. Reverse view of wad (far left) shows details of molding. Wad is ¾ in. wide and ⅜ in. deep (including nipple).

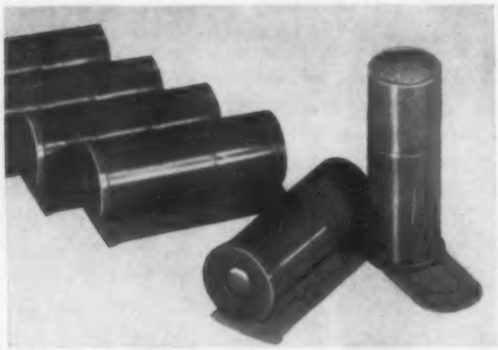
the injection molding process, the wads could be designed with intricate ribbing, wedging lips, molded-in holes, carefully controlled tapers, and still be competitive:

1. The flat surface of the wad transfers the first forces of the primer explosion through the molded-in ribs, expanding the diameter of the wad at its base, wedging it in place for a time sufficient to improve powder confinement and uniformity of powder ignition—which eliminates muzzle flashes.

2. The air cells designed into the wad (by molded-in ribbing and separator) aid in the wedging action; however, they also cushion the violent action of a smokeless powder explosion—which improves pattern and makes recoil less noticeable.

3. Finally, by designing the sealing lip with a radius increasing toward the base from the lip, maximum gas sealing was obtained.

The wads are molded on a Netstal Rotomat Model 260/500 (5 cycles/min.). The weight of each shot is 16 grams. They are sold nationally at firearms, sporting goods, and similar stores at a list price of $5.95 per 1000.



REVOLVER CARTRIDGES of high-density PE (Colt) are loaded with wax bullet.

PROJECTILE of polyethylene, body of nylon, and primer; that's the sum total of parts for revolver training shell.

Shell-casing adaptor

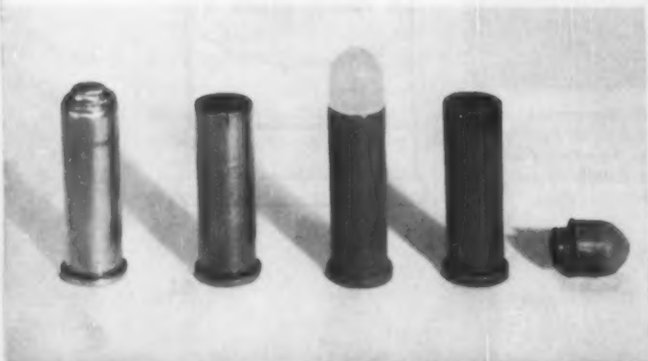
Another development still in the experimental stage is concerned with the problem of using small gauge shells in a shotgun of larger gauge. This problem is an old one and in the past has been solved through the use of barrel adaptors. These are, in effect, smaller gauge barrels that fit into the regular shotgun barrel. The trouble with this type adaptor is that it cannot be used on some guns and is inconvenient in others.

Can this problem be tackled by way of the shell rather than the barrel?

Experiments conducted by Phillips Chemical Co. give an affirmative answer. And by using Marlex high-density PE shell-casing adaptors, the company, in effect, increased the diameter of the shell. The casing, which is ejectable and reusable, is essentially a cylindrical cover into which the smaller-gauge shell fits. Test results look promising, and indicate clearly that plastics' design potential in this application will tend to make the 12-gauge shotgun more universal, more than ever better able to handle available loads for a greater range and variety of shooting conditions.

Training bullets at lower cost

The case for cost-reduction by plastics in training ammunition was first reported for mortar shells (see "ABS shells save $14 per firing," MPl, Feb. 1960, p. 90). Now plastics have moved into pistol ammunition as well and are bringing similar economies. While the mortar shell used acrylonitrile-butadiene-styrene polymer blend material, the (To page 186)



BRASS CASING (far left) before firing and after minor use (second from left, note unretouched crack at top). Nylon casing and PE bullet (third from left) before firing, and after 100 shots (extreme right). While somewhat blackened, both casing and projectile are still structurally sound.

TOMORROW IS TODAY FOR

Vinyl films, sheets, coatings in construction

In competition and in combination with traditional materials, these vinyl forms have achieved significant penetration of the multi-billion-dollar construction market

The oft-heard lament that plastics' share of the booming construction industry is just a poor 1 to 2% loses much of its force when it comes to the vinyls. For here is a plastic that has made solid inroads in the $15.5-billion-a-year market for primary construction materials, and that has also forged for itself a promising future.

All this has been done in the face of obstacles, such as antiquated codes, building industry conservatism, competition from other materials, and lack of marked consumer demand, that have stymied many another plastic. Vinyl's success is indicated by the incorporation of an estimated 254 million lb. of vinyl resin in building products today, a total well ahead of the other plastic materials.

Even in those areas of construction where a competitive all-vinyl product does not now exist, vinyls especially in the form of films, sheets, and coatings, have combined with traditional materials that have already carved out tremendous market volume. This has not only widened the outlets for vinyl resin, but also has broadened the industry's base by bringing in segments of the economy that had never before had anything to do with plastics.

Underlying the success of these products, whether all-vinyl or with vinyl components, has been the rise of construction costs in this country. These costs went up an average 2% within the past year, and a further increase of from 3 to 4% is foreseen for 1961 by analysts of the construction picture.

Since the average 2% increase includes both material *and* labor costs, relief for the architect and building contractor has to come in

For similar coverage of construction applications of rigid and semi-rigid extrusions, see Part I, MPI, Oct. 1960, p. 83.

LAYER OF VINYL FILM is applied over roof deck by workman (right foreground) using roll applicator. Strips of hot tar are brushed on film to seat insulation panels, over which asphalt sheet is applied, also with roll applicator (background). This will then be topped with hot tar mopping. Vinyl film layer provides moisture barrier, protects roof from hot tar drippings in event of fire. Photo, Monsanto Chemical Co.

Photo, B. F. Goodrich Chemical Co.

CALENDERED VINYL FILM fitted around shower bottom before workman installs tiles, acts as moisture barrier in stall shower construction. Vinyl film does a considerably better job at lower cost than sheet lead, asphalt felt, and copper barrier materials.

the form of materials that are not only inexpensive, but also can be pre-assembled, quickly installed, and easily maintained. It is largely on the basis of supplying these needs that the vinyls have reached their present market position in the construction industry.

Just how extensive are the vinyl applications in the building industry? Here are some of the major successful construction applications for vinyl coatings, film, and sheet.

The combination approach

Vinyl coatings, applied to traditional construction materials having the desired structural strength, add an abrasion and weather-resistant surface, integral color, sound-deadening and insulative qualities, and a pleasing warmth to the touch. Many of the products formed from these combination materials have tremendous market potential. To give an example, it is estimated that some 275,000 homes will be covered with vinyl-coated aluminum siding this year, a 50% increase over 1959. And prognosticators now talk about the use of this same siding on about 1 million homes by 1970!

A rosy view is also presented for vinyl coatings on other substrates, such as steel, gypsum board, wood, and concrete, and for products other than siding, such as shingles, gutters and downspouts, doors, and interior wall panels. One published estimate has placed sales of all vinyl-coated metals at about 40 million sq. ft. in 1959. Assuming an average selling price of 40¢/sq. ft., this was a $16-million market last year. Also, vinyl resin producers and coating formulators can happily contemplate potential use of their products in the construction markets for gypsum board, estimated at 7.3 billion sq. ft. in 1959, and for softwood lumber, estimated at 29.5 billion board feet.

It is interesting to note that much of the initial impetus for widespread use of the coatings came from firms that had little previous experience with plastics. The list of names includes such large and well-respected companies as Reynolds Metals, Alcoa, U. S. Steel, National Gypsum, and others. When still more companies follow the lead of these trailblazers, vinyl usage should soar.

Solution coatings hold top place

The great majority of today's vinyl coatings are of a solution type, consisting of vinyl resin, solvent, plasticizer, and pigment. Plastisol and organosol types, which form heavier film coatings, make up the rest of the total. Generally speaking, the resins used in these coating systems are copolymers of vinyl chloride with vinyl acetate. There is reportedly on the market an organosol coating which contains a high solids content of straight vinyl chloride resins, but experience with coatings of this nature, and exposure test data on them, is limited.

Vinyl coatings on aluminum and steel are applied by continuous roller coating or spraying processes to base stock before the final product is made. Pre-fabrication coating is possible because the vinyl can withstand the forming, punching, or bending stresses encountered during fabrication. Wood and concrete are usually in structural form, *i.e.*, finished buildings, before the protective vinyl coatings are added, generally by spray gun techniques.

One of the most outstanding uses of this technique can be seen in the "theme" building of the new Los Angeles International Airport. The structure, now being built, will consist of two great parabolic arches, the legs of which will touch the ground across a diameter of 340 feet. Suspended from the arches will be a 100-ft.-diameter saucer of glass, steel, and concrete which, like the arches themselves, will be sprayed with vinyl to a thickness of 40 mils.

Several manufacturers of fiber board and gypsum board are using a vinyl latex coating as a moisture vapor barrier on their products. The coating, factory-applied by roller-coating or spraying, is said to provide moisture vapor protection comparable with polyethylene film,

which must be applied by hand stapling at the construction site. The vinyl coating has the necessary cost savings, as indicated by the following figures: based on 100 sq. ft., material cost is 59¢ and installation cost 10¢ for a 2-mil latex coating. Material cost for 2-mil PE film is 85¢ and installation cost is $1.45.

Cost savings are also cited for finished vinyl-coated products. As a representative example, Hastings Aluminum Products Inc., Hastings, Mich., estimates that the contractor can save an average $300 per installation of Hastings' vinyl-coated aluminum siding over the cost of wood siding. It is said that the costs of installing the wood siding, including labor, are higher than the average installed cost of 80¢/sq. ft. for the coated siding. Another example is the vinyl-surfaced gypsum wallboard, known as Durasan, made by National Gypsum Co., Buffalo, N. Y. Retail price of 25 to 27¢/sq. ft. for the coated wallboard is higher than that for regular gypsum wallboard, but this extra cost is offset by the elimination of joint refinishing, decorating, and maintenance for the vinyl.

The decorative function is an important factor, particularly with vinyl-coated steel, which is primarily intended for interior use in products such as doors, room ducts, and inner surfaces of curtain wall panels. The costs of vinyl-coated steel are said to be higher than those for painted or embossed steel, but the vinyl coating provides a variety in surface texture not available with other products. Based on typical quantity orders, representative costs of 10-mil vinyl-coated steel sheet from U. S. Steel range from below 20¢/sq. ft. for 28- to 30-gage steel to around 32¢/sq. ft. for 18-gage steel. Some of the vinyl-coated aluminum siding products also offer a textured surface, which in no way detracts from the protective qualities of the coating. An example is the siding manufactured by Solmica Inc., St. Louis, Mo., which is available in simulated redwood or mahogany grain finishes.

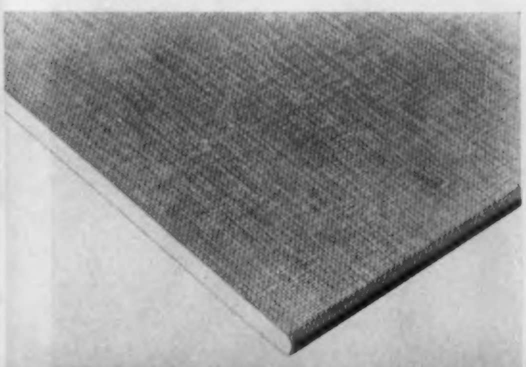
Plastisol coatings on aluminum wire and on glass fiber strands provide corrosion and abrasion resistance and integral color to screening products. The coated aluminum screening, made by New York Wire Cloth Co., York, Pa., consists of a 9-mil aluminum core covered with a 4-mil plastisol coating. The metal strands are individually drawn through a series of troughs containing the vinyl plastisol bath, then are forced through dies to control the vinyl thickness. This process, known as die wiping, is also used for the vinyl-coated glass fiber screening made by Chicopee Mfg. Corp., Lumite Div., Buford, Ga. Owens-Corning Fiberglas Corp., Toledo, Ohio, supplies the glass strands, while the coating is formulated by Chemical Products Corp., Providence, R. I., using resins from B. F. Goodrich Chemical Co. This screening is extremely light, about 4 lb./100 sq. ft. (for comparative purposes, the vinyl-coated aluminum screening weighs just 5 lb./100 sq. ft.), and has an estimated potential volume of about 500 to 600 million sq. ft. per year.

Vinyl film and sheet

Consumption of vinyl film and sheet for construction purposes has been estimated at 30 million lb. for 1959. One of the prime film uses is in moisture vapor barriers, which probably account for some 3 million pounds. The future of the film barriers will undoubtedly be deter-

Photos, National Gypsum Co.

VINYL COATING on gypsum wall panel provides stain-repelling, abrasion-resistant surface that needs no further decorating. Panel shown here can be cemented or nailed to wood framing. Close-up of panel, below, shows fabric-like texture of vinyl coating, and beveled edges which form joint when they are butted together.



mined by the extent of competition from vinyl latex coatings and from polyethylene film.

The moisture vapor barriers are generally of calendered, plasticized vinyl chloride film. They may be used in roof construction, around windows, over foundation work, or where seepage of moisture deteriorates underlying materials.

Costs are well in line with other materials. For example, the average installed cost of a 4-mil vinyl film moisture vapor barrier is from 5 to 7¢/sq. ft., which is said to be comparable to the cost of vapor barriers made from asphaltic materials. Further economies may often come from the increased service life of the vinyl film. This is illustrated by the use of vinyl film as a moisture barrier around windows. One large contractor, Kalikow Construction Corp., Brooklyn, N. Y., reports that it uses 8-mil vinyl film in window construction to replace the previously-used tar paper. Despite the fact that the tar paper cost 2¢/sq. ft less than the vinyl film, it lasted only one-third as long. Often the tar paper tore immediately upon installation.

Codes okay film for shower stalls

The economics of vinyl film as a moisture barrier in stall shower construction is undeniable. A majority of community building codes now accept the vinyl material as an alternate for sheet lead, copper, or asphalt felt mopped with hot tar. An estimate by Sealzit Co. of America, Riverside, Calif., producers of such vinyl materials for shower pans, indicates these savings in average installed cost for a 48 by 48 in. shower: the vinyl film moisture barrier costs $7.35, well below the $12 for asphalt felt, the $28 for sheet lead, and the $34 cost of a copper lining.

One of the most interesting construction applications for vinyl sheet is an outgrowth of the trend in some television studios to produce their own props from thermoplastic sheet. The product, a decorative house shutter measuring 15 in. wide by 5 ft. high, is vacuum formed from high-impact vinyl sheet by Columbia Broadcasting System Inc., New York, N. Y. The sheet was manufactured by Seiberling Rubber Co., Plastics Div., Newcomerstown, Ohio, from BFG Chemical vinyl resin. Commercialization of the shutters is expected when distribution outlets become available.

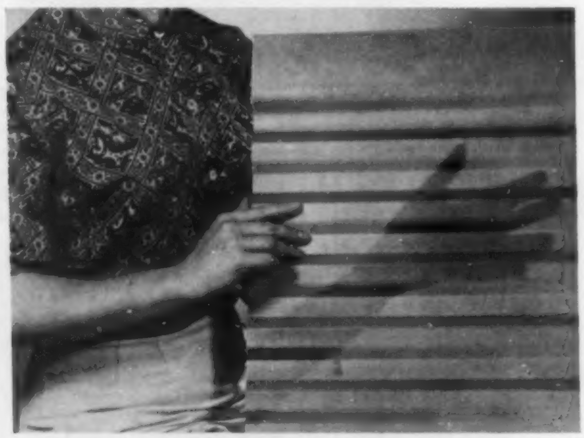
Based on costs for extrusion and forming of rigid vinyl sheet, it has been estimated that the shutters will sell at about $11 to $13 per pair. Since the vinyl shutters do not require painting, will not rot, split or warp, and are resistant to weathering, the cost will compare favorably with unpainted wooden shutters selling for about $11 per pair.

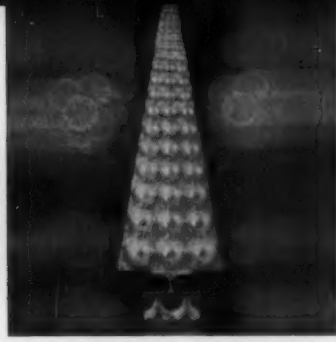
Self-extinguishing structural glazing and partitioning are applications foreseen for a corrugated translucent vinyl sheet jointly developed by National Rubber Machinery Co., Akron, Ohio and BFG Chemical. (To page 182)

VINYL SHUTTER, to be marketed in near future, will not rot or warp like wooden models, yet will reportedly carry comparable price on the retail market. Shutter is vacuum formed from vinyl sheet. Light weight of shutter will make handling and installation a simple job.

Photos, B. F. Goodrich Chemical Co.

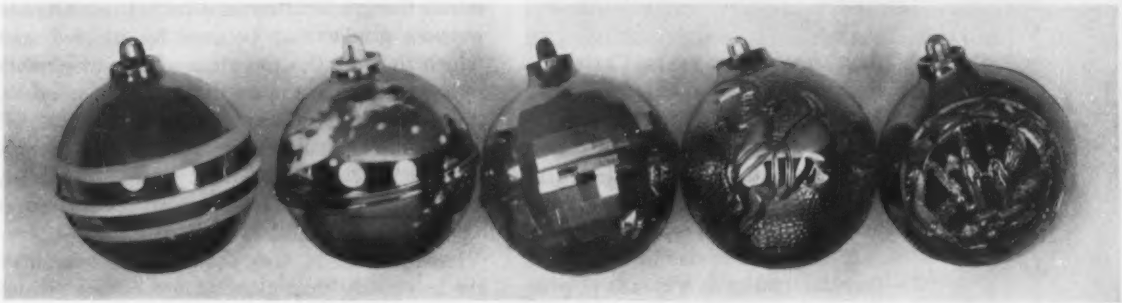
DESIGNED for structural glazing and partitioning, corrugated translucent vinyl sheet is extruded by continuous process. Key to production is a 52-in.-wide sheet die teamed with post corrugating form, both developed by National Rubber Machinery Co.





REVOLUTION in design and beauty of Christmas decorations through increased use of plastics is represented by this thermoformed styrene display tree, by W. L. Stensgaard Assocs., vacuum metallized in gold. In background, colorful effect is created by motion of internally-lighted hanging ornament vacuum formed of butyrate by General Plastics Corp.

Plastics in the product revolution: CHRISTMAS DECORATIONS



UNBREAKABLE CHRISTMAS ORNAMENTS are molded from impact styrene, decoration by vacuum metallizing operation. Plastic balls cost less than glass, have greater design flexibility. Note fine filigree work on two ornaments to right.
Photo, Bradford Novelty Co.

The emergence of plastics as a major design material for Christmas decorations has enabled the American public today to enjoy the safest, most colorful holiday season in history.

Developments in plastics materials and manufacturing processes since the 1940's have resulted in decorations that are virtually unbreakable, flameproof or relatively slow to burn, inexpensive enough to be within the reach of nearly every consumer, and exceedingly varied in shape, size, and color. On the commercial level, retailers can now present more colorful displays of their merchandise during one of the most important selling seasons of the year, without the hazards of fire or breakage of the display materials.

Plastics first entered the Christmas decorations market in a small way around the end of World War I. Urea, and general purpose phenolic somewhat later, appeared in molded sockets and plugs for tree light sets, replacing the conventional wood-filled shellac. Tree ornaments in this period were generally of glass, cloth, and wood materials.

Many of the glass ornaments on the domestic market were imported from Europe. There was great demand for internally-lighted glass figures (angels, trees, candles, etc.) from Czechoslovakia. Known as "fancy lamps," these items were actually filament bulbs blown into intricate Christmas shapes. However, while initially beautiful, the carbon filament usually became so hot that the painted decoration on the bulbs soon peeled off. These lamps generally disappeared from the domestic market in the period between the wars.

Although plastics continued a steady progression into the decorations market in the 30's, the flammability of many materials then available prevented any large-scale breakthrough. A big boost came later in this decade with the introduction of polystyrene for injection molding of representative Christmas figures. Decorations produced from styrene were less hazardous than those produced from wood and paper, and the material was also translucent, enabling decorative lighting firms to expand their lines from glass tree lights to internally-lighted plastic figures.

Flame-resistant cellulose acetate became popular around 1946 for the injection molding of small bells, candles, Santa Claus figures, and

Photo, Bradford Novelty Co.

POLYETHYLENE COVERING, extruded in tubular net form, contains colorful polystyrene ornaments. The unique product, designed to be draped around Christmas tree, represents the first application of the netting (Du Pont Vexar) in the Christmas decorations market.

angels for both residential and commercial decorations. Use of polyethylene is reportedly limited by the difficulty in decorating Christmas items made from the material, but items requiring no post-decorating, such as artificial Christmas tree components and molded bells, are widely used today. In recent years Christmas figurines of blow molded PE have appeared on the market, but manufacturers feel that injection molding obtains better detail in decorations and is less expensive in large volume work.

A tremendous rise in the use of thermoforming as a means of producing larger, display-size Christmas decorations occurred around 1950. Cellulose acetate and styrene sheet were early materials in this field, and were soon joined by rigid vinyl, butyrate, and some polyethylene materials. Over the past 10 years, the popularity and pre-eminence of thermoforming in the Christmas decorations field has not diminished. According to some producers in the decorative lighting market, the use of thermoforming could increase by 100% in two years with the introduction of a more highly-polished thermoplastic sheet at a reasonable price. The reasoning behind this is that the calendered sheet available today lacks a high gloss, an important factor to the retailer who must sell decorative lighting products "cold," i.e., not lighted.

For extreme light-weight and flexibility in design, polystyrene and urethane foam have gained acceptance recently as materials for Christmas items ranging from wreath cores to fancy store displays. Pressure forming has been used for Christmas tree balls and back-lighted display signs, generally produced in clear acetate, which is later sprayed or vacuum metallized. Greater detail and faster forming cycles obtainable with the higher pressures of this process enhance its potential in the Christmas decorations market. Pressure-formed ball ornaments made by Plaxall Inc., Long Island City, N. Y., are featured annually on the huge Christmas trees at the White House and at New York's Rockefeller Center.

Ornaments

Most of the plastic tree ornaments on the market today are of polystyrene, injection molded and decorated by vacuum metallizing. Molding has proved to be the most economical method of production and vacuum metallizing the most satisfactory method of decoration. The degree of exposure to breakage usually determines the grade of styrene resin used. General purpose grades may be used for molded stars which fit over the top stem of the tree, while impact grades are more desirable for pendant-type ornaments. Compared to glass balls, PS ornaments are superior in resistance to breakage. Moreover, their great design flexibility has made possible shapes that could never have been produced in glass.

Item for item, the polystyrene ornaments are less costly than glass. One company, which markets the plastic ornaments exclusively, cites these comparative figures: a 2-in. ball in plastic, priced at 10¢, would cost about 15¢ in glass, while a 3-in. ball in plastic would be 15¢, compared to 19¢ for the same ball in glass. One unique Christmas ornament, introduced by Bradford Novelty Co., Cambridge, Mass., consists of several PS balls covered with Du Pont's Vexar extruded netting in chain fashion.

Vacuum-formed displays

Vacuum formed signs and displays, primarily for commercial applications at Christmas time, have grown rapidly in size, complexity, and popularity. Advances in thermoforming technology, permitting plastic part sizes up to 12 ft. by 4 ft. wide, have contributed to the growth.

Displays for indoor use are usually of polystyrene or vinyl sheet. The latter material is particularly desirable for its self-extinguishing properties. W. L. Stensgaard & Assocs. Inc., Chicago, Ill., favors PS for its sturdiness after forming, basic low cost, and ability to be easily spray painted or vacuum metallized. Displays produced from high-density PE or butyrate for outdoor applications offer a higher degree of weather resistance and light stability.

Christmas trees

Artificial Christmas trees of plastic have become more sophisticated in appearance over past years. Among the plastic products are

aluminum-metallized vinyl trees (Noma Lites Inc., New York), trees produced from saran microtape (B&S Novelty Co., Brooklyn, N. Y., using Dow Chemical's Rovana), and assemble-yourself trees of PS and PE parts, injection molded by Warren Industries Inc., San Bernardino, Calif., are fitted together by the customer to form the finished product, and later taken apart for storage.

Halvorson Trees Inc., Duluth, Minn., markets about 1½ million natural trees each year with butyrate sleeves containing synthetic sap fitted between the tree stem and a metal stand. The plant nutrients contained in the molded sleeve keep the tree from premature shedding of needles.

As decorative accessories for the trees, metallized saran tinsel, made by Ben-Mont Inc., Bennington, Vt., has become a strong competitor of lead and aluminum "icicles." The plastic tinsel does not cling to itself and will not ignite from heat of tree lights. Similar products include metallized PVC tinsel and tree and wreath bows of metallized Mylar polyester film.

Christmas wreaths

In the wreath market, molded polystyrene foam cores have replaced earlier wire frame and hay cores. Novelty Wreath Co., Philadelphia, molds beads of polystyrene (Koppers Dylite) into long tubes, which are then cut into the cores. The foam core is trimmed on a production-line basis: pine cones, berries, bells, etc., are wired to dagger-like wooden pins, then sent to workmen who quickly jab them into the foam core.

The artificial wreaths are generally produced from extruded polystyrene filaments, about the base of which lengths of wire are braided. As the wire is twisted, the filaments arrange themselves in brush fashion around the wire core. Leaves of holly and poinsettia for the wreaths can either be molded of polyethylene or stamped from vinyl sheet, and have replaced "leaves" of rayon acetate on many artificial wreaths today.

Foreign competition

Small specialty items from Japan are quite common on the domestic market today. Many of these plastic, wood, and cloth items display a wide and often wild application of the imagination, and as a rule, American manufacturers do not compete in this area. Foreign-made products that are internally lighted offer stiffer competition; however, domestic firms can stress safety to the customer since their products are approved by Underwriters' Laboratories. Moreover, the domestic producer of plastic ornaments can emphasize safety for his products, in this case their excellent resistance to breakage. Also, if the imports are of plastic, they are rarely vacuum metallized, and the domestic product has the edge in decorative effect.

American firms using plastics for Christmas decorations have found that the materials have contributed to improvements in strength, attractiveness, and variety in design, improvements which represent the best method of keeping world leadership.—End

VACUUM FORMED butyrate sheet is used in these giant display pieces designed for outdoor use and retail displays. Sheets are formed in two halves, solvent-cemented or bolted together.

METHOD OF PRESERVING natural Christmas tree uses molded butyrate sleeve (center foreground) in stand holding liquid nutrient. Sleeve is fitted by means of metal ring into tree stand at right. Cross section views in background show how new method (left) permits more contact between tree stem and nutrient than old method (upper right), in which stems were doweled down to fit into stands.

Photos, Eastman Chemical Products Inc.

AUSTRALIAN

Winning entries feature ingenuity of design concepts, show high level of plastics accomplishment

CHARLES A. BRESKIN (right) awards F. H. Edwards Plastics' Industry Laurel to J. Fraser-Hope of Moulded Products (A'asia) Ltd. for collapsible acid bottle, top award-winner in the Industrial Products under-3-ft. classification.

As a continent, Australia may be down under; but in terms of plastics achievement, it's way up. This fact was firmly established at the recently held Australian Plastics Convention and Exhibition (see MPl, Nov. 1960, p. 91). And it found its most striking expression in the winning entries to the F. H. Edwards Plastics' Industry Laurel awards. The Laurels were established by Mr. Edwards, a leader in the Australian plastics industry, as an incentive to his colleagues to maintain their standards of quality at top level. They were presented this year at the National Plastics Week dinner, held in Sydney on Oct. 6, 1960, by Charles A. Breskin, Chairman of the Board of Breskin Publications Inc., and founder of MODERN PLASTICS and *Modern Packaging* magazines. Mr. Breskin was in Australia as the guest of honor of the Plastics Institute of Australia.

Public is made more plastics-conscious

The dinner was the culmination of an exciting Plastics Week, during which numerous segments of Australian business and industry joined in hailing the country's plastics accomplishments. Stores throughout the major cities were appropriately decorated, and their windows keyed to the plastics convention. Thanks to the organizational efforts of the Institute, the populace was made more plastics-conscious than it ever had been.

The competition for the Laurel awards is divided into three groups: I) Industrial and consumer items over 3 ft. in any dimension; II) consumer products under 3 ft.; and III) industrial units under 3 feet. The winners are illustrated and described in the accompanying photographs and captions. In addition, several entries received honorable mentions. These awards were given as follows:

Group I: Auto Assemblers Pty. Ltd., Gee-, long, Victoria, for a reinforced plastics Sunliner trailer; Reinforced Plastics Pty. Ltd., Oakleigh, Victoria, for a 300-amp. welding set housing assembled from molded glass-reinforced polyester parts.

Group II: Moulded Products (A'asia) Ltd., Richmond, Victoria, for a molded high-impact polystyrene canister set; Academy Plastics Pty. Ltd., Richmond, Victoria, for a 5-in. molded high-density polyethylene fishing reel.

Group III: L & I Glenn, Kingsway, Moorabbin, for 5-gal. blow-molded Jerry can; Sturdee Electricals Pty. Ltd., Clayton, Victoria, for a molded combination switch and plug socket; Moulded Products (A'asia) Ltd., for its vinyl-clad metal television cabinet.

All these winners represent an advanced level of sound plastics design and engineering. In each case, processors all over the world may well find ideas and suggestions that they may adapt to their own particular requirements. Thus do the plastics industries become truly international.—End

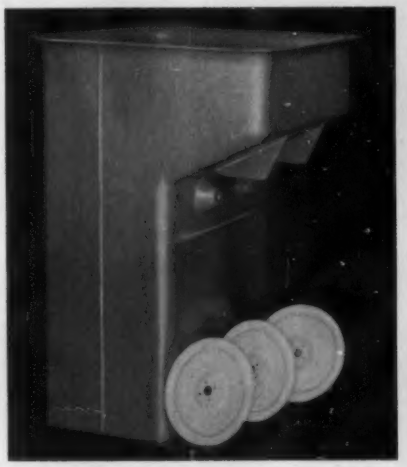
PLASTICS AWARDS

Industrial and consumer products over 3 ft. in any dimension

First Prize:

Aerial platform basket, produced by Reinforced Plastics Pty. Ltd., Oakleigh, Victoria, for Queen's Bridge Motors Pty. Ltd.

By designing the personnel-carrying gondola of a maintenance crane in molded fibrous-glass reinforced plastics, a number of advantages were achieved: good strength combined with light weight, weather resistance, and electrical insulation. The gondola, attached to an hydraulically-operated 25-ft. steel arm mounted on a motor truck, is used in regular maintenance of street lighting, erection of signs, building maintenance, and any job that requires the operator to work off the ground in awkward-to-reach places. Baskets made in steel would be so heavy that they would reduce payload and increase power requirements. They would also need protection against hazards of electrical shock and corrosion. Three reinforced plastics wheels in the basket control movement in three planes—up and down, forward and back, and sideways. The basket can carry a total load of 500 pounds.



Consumer products under 3 ft.

First Prize:

All-nylon paint brush made by Victorian Diemoulders Pty. Ltd., Geelong, Victoria.

This product is an excellent example of how, through molded plastics, complexity can be reduced to simplicity. Conventional paint brush assemblies (handles, ferrules, wooden wedges, rubber, nails, and rivets) formerly used automatic wood-shaping machines, machines for steel press work or drawing operations, and such other equipment as painting and enameling units, drying ovens, etc. All of these entailed considerable material waste and a multitude of manufacturing processes. The new brush, designated the Rockset, is an all-nylon assembly composed of only two parts. Each part is produced on automatic machines, with no material waste and with a significant reduction of labor costs. Nylon was chosen because it was not affected by the various solvents and chemicals with which it would come in contact. It would also withstand differences in temperature and humidity encountered in normal painting operations.

Industrial products under 3 ft. in all dimensions

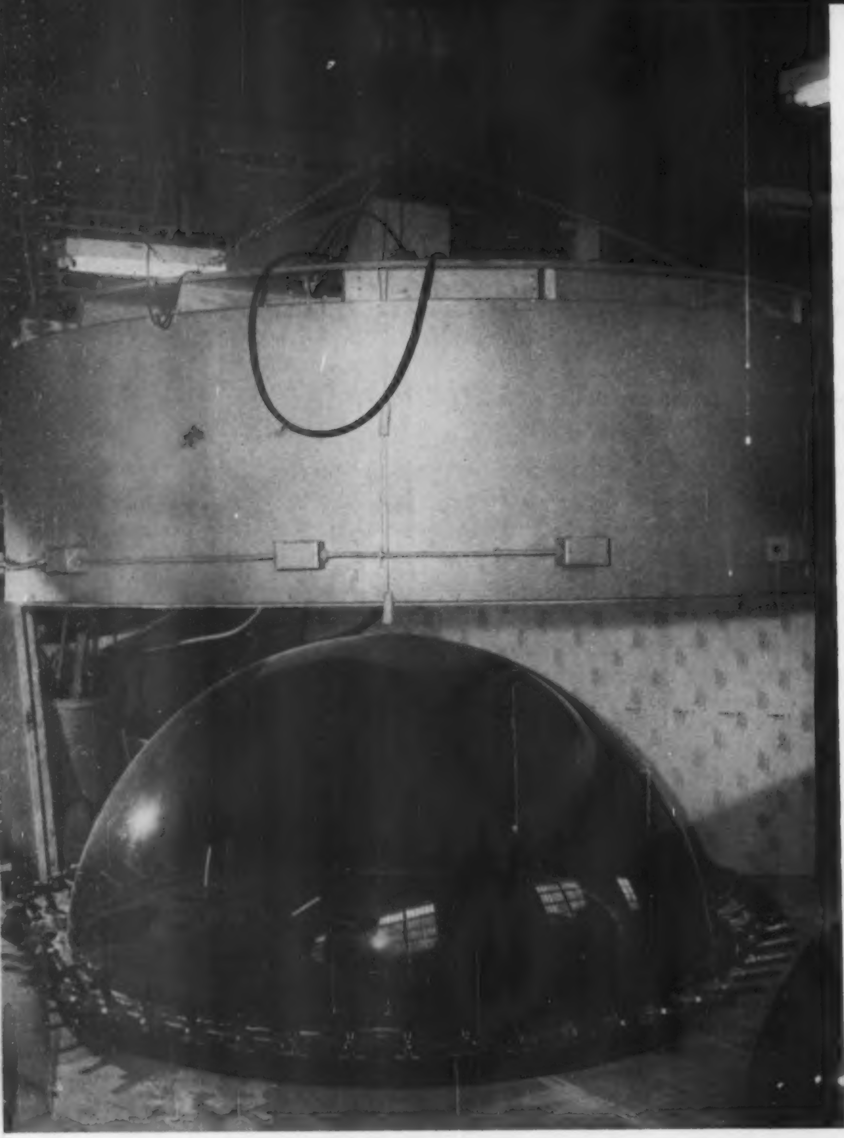
First Prize:

Collapsible acid bottle, blow molded of polyethylene by Moulded Products (A'asia) Ltd., Richmond, Victoria.

The containers when empty collapse to one-third their filled height. They are being used by one of Australia's largest battery makers. The company sends the bottles to Perth, where they are filled with sulphuric acid for nearby distribution. The savings in freight costs resulting from shipping these bottles collapsed are considerable. Normally, when bottles are shipped empty over long distances, they are charged at the rate of full bottles—by volume rather than by weight. When the bottles are filled, a screw-on sealed pourer is fitted; for pouring, the top of the spouts are cut off. Bottles are produced in 0.6-, 0.8-, and 1.2-gal. capacities.

Full-cycle

Elevating heater unit warms sheet in place on blower, rises with growing bubble to maintain even temperature for uniform dimensions



↑ **ELECTRICAL HEATING UNIT** (top) is integrated with blowing equipment (bottom) in new process for free-forming of acrylic domes. While dome is rising, heater is manually raised with it to provide uniform heat, prevent formation of bulges that destroy bubble shape.

→

TRANSPARENT acrylic globe houses model of uranium atom, part of lobby exhibit in Union Carbide Corp. headquarters building in New York City. Display globe consists of two dome halves (see photo above) bolted together through side flanges.

heating blows better acrylic domes

Uniform heat is the key to control of quality in a new method of free-blowing large domes from heated acrylic sheet. The process, developed by Plasti-Vue Co., Whitestone, N. Y., insures the formation of a true bubble shape in the finished dome, and can also provide savings in the cost of labor.

In the conventional free-blowing process, the acrylic sheet is heated in an oven separately, before the blowing operation. The hot sheet must then be carried by hand to the blowing apparatus, and as many as 20 men, each equipped with asbestos gloves, may be needed for this transfer. During this extra handling step, a drop in sheet temperature is inevitable (sometimes as much as 30° F.), and a wasteful amount of air pressure is required for blowing.

Perhaps the biggest problem with conventional free-blowing is that the thinning sections of the forming bubble cool more rapidly than the thicker sections near the base, and the air pressure often forms a shape-distorting bulge in this still-warm section. Also, handling time is limited to about 3 min. once the acrylic sheet is taken from the oven.

The important difference

The new method differs from normal free-blowing in a fundamental way: heating is done with the sheet in blowing position. Transfer of the sheet from heating to blowing equipment is thus eliminated and the manpower required significantly reduced, resulting in labor cost savings. Sheet handling time is practically unlimited, since heat may be applied as long as needed, and two workmen can easily operate the entire process. The greatest advantage, according to William Barber, Plasti-Vue president, is that, with heat kept continually on top and bottom portions of the dome as it is forming, distortion of the bubble shape due to uneven heat distribution is eliminated.

Much of the equipment used in the new process was custom-built by Plasti-Vue. About 5000 lb. of steel went into construction of both the circular plywood-faced backplate and the overhead electric heating unit, which is a circular hood with a 30-in. hot air-dispersing fan in the center. Other processing equipment and fixtures include: a custom-built ring jig of steel and Masonite construction, a 5-h.p. air compressor and clamping fixtures, and a hoist to suspend the heating unit over the backplate.

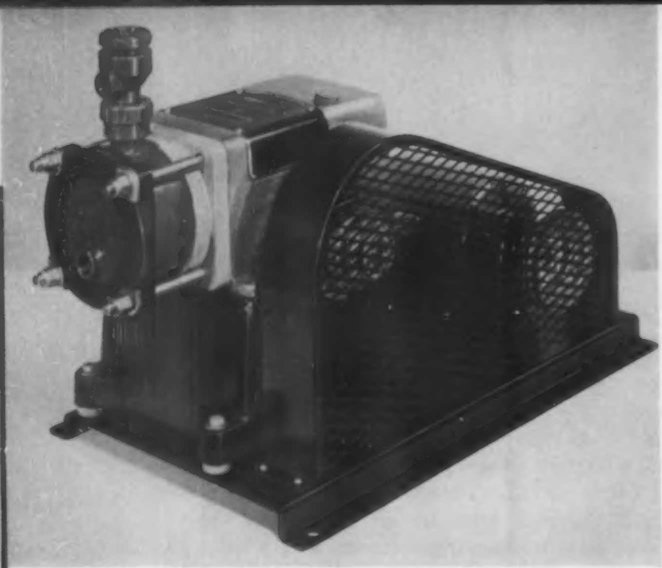
How the process works

In forming a dome by the new process, the acrylic sheet is first placed horizontally on the plywood-faced backplate. The ring jig is placed over the sheet and tightened by the clamping fixtures on the periphery of the backplate. The heater is manually lowered over the sheet by the hoist, and the heating cycle is started. The hot air is evenly distributed over the entire area by the heater's fan.

When the acrylic sheet has been thoroughly and uniformly heated to a temperature of about 350° F. (in about 1 hr.), the air is turned on. Air is fed at 10 p.s.i. underneath the backplate to a center vent, which is fitted with a baffle to distribute the air equally to all sections of the heated sheet. As the acrylic bubble expands to shape, the heater is raised with it to keep heat on thinning areas of the bubble at all times.

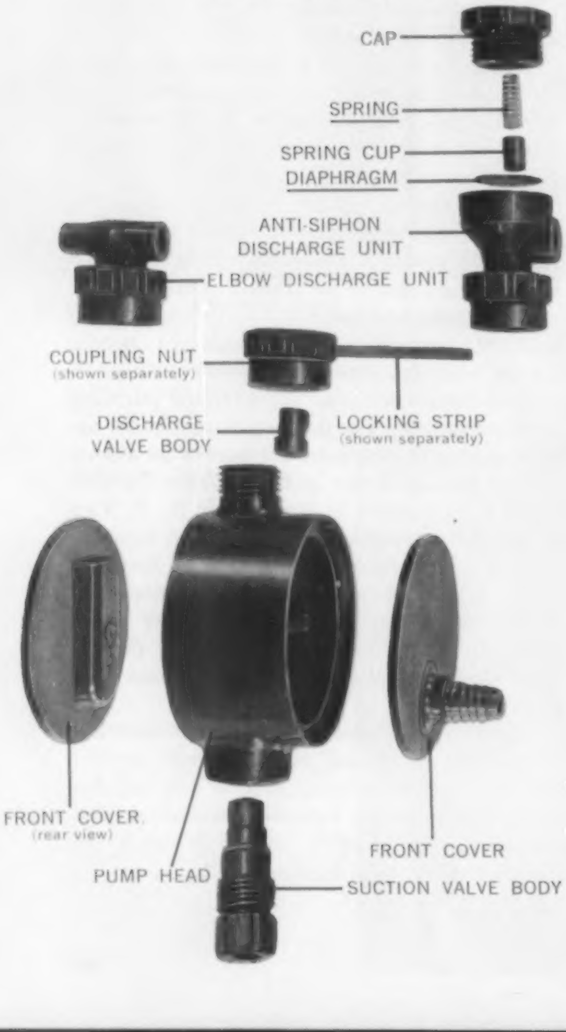
Advertising and institutional displays are the primary applications for free-blown acrylic domes, although several produced by the new method have been used for scientific purposes by observatories. The domes pictured in the accompanying photographs are part of an atomic energy display in the lobby of Union Carbide Corp. headquarters in New York, N. Y. Two of the transparent domes were bolted together to form an 8-ft. diameter globe, which houses a model of the uranium atom. The domes were blown from blue methyl methacrylate discs, ½-in. thick and 102 in. in diameter, die-cut from sheets supplied by Rohm & Haas Co., Philadelphia, Pa.

Introduction of the Plasti-Vue free-blowing process for producing acrylic domes proves that the plastics industry in 1960 can still develop new twists in venerable techniques for fabricating well-known materials such as methyl methacrylate sheet.—End



DIAPHRAGM PUMP for chemical feeding has head assembly molded of Penton chlorinated polyether. Light colored mounting plate is molded of polyester premix. Base is now of metal, but is currently being redesigned for molded premix, too.

EXPLODED VIEW of pump head. All parts are of Penton except those underscored.



PENTON

By going to molded Penton chlorinated polyether components, Wallace & Tiernan Inc., Belleville, N. J., has succeeded in extending the application of its diaphragm pumps from limited use with water-treating chemicals to such corrosive compounds as chromic acid, potassium permanganate, sulfuric acid. And what's most important, they did it without investing a penny in additional tooling cost!

Prior to the adoption of Penton, (a product of Hercules Powder Co.), Wallace & Tiernan made these pumps with modified styrene heads. The chemical resistance of this material was high enough to handle most water-treating compounds; and the pumps found extensive usage in swimming pool and sewage treatment, water purification, and the like. The transparency of modified styrene was an added bonus, since look-through visibility in these applications is frequently required by local law. To serve these markets, Wallace & Tiernan will continue making modified styrene parts. But by using the new Penton head, while retaining all other body components, the company has now branched out into many new and interesting industrial areas.

Of course, with the price of Penton being over six times as high as that of modified styrene ($2.50/lb. versus 40.5¢), pump costs are increased. But, compared to pumps especially designed for corrosive applications, they are still low. Cost of the pump shown in the illustration at left, completely packaged with fittings and all necessary equipment, is $360 with a modified styrene head; with a Penton head, this same package costs $410. Thus, for the price of $50 extra, the user gets what is essentially two pumps.

Some molds used for both plastics

Behind this small cost increase is the fact that no tooling expenses are involved. The Penton parts are molded in the same molds as the

A switch to chlorinated polyether, despite its premium price, achieves economy by making water-treating pumps serviceable in corrosive acid systems

creates two pumps in one

modified styrene components. It is true that Penton shrinks differently from the modified styrene. But all Penton parts shrink proportionally; and, since the mounting tolerance is not considered critical, the higher shrinkage of Penton represented no specific problem. Shrinkage for the front cover for example, was 1/16 in. on a 4¾-in. diameter.

All parts are molded by Boonton Molding Co., Boonton, N. J., in single and double-cavity molds. Molding cycles are essentially the same as used for the modified styrene parts; but the mold is run at 190° F.

Total weight of Penton parts is 2¼ lb.; total annual production of such pumps is about 500.

For Wallace & Tiernan, which has used plastics increasingly in much of its equipment, the new pump represents an efficient way to round out its line. To the plastics industry, the development points up the economic advantages that can be gained by the judicious choice of premium-priced materials.—End

And in rotameter plugs . . . Penton adds to service life

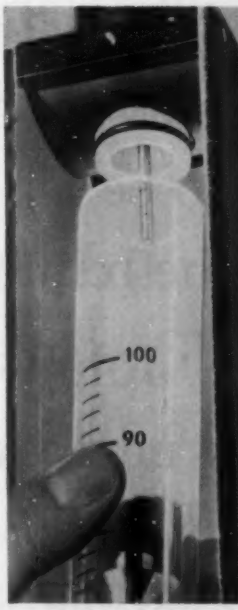
Improved performance and reduced costs were the twin benefits Brooks Rotameter Co., Lansdale, Pa., achieved by switching from stainless steel and TFE fluorocarbon to Penton chlorinated polyether adapter plugs for its line of rotameters.

A chemical rotameter, a device to indicate and control flow rate, utilizes a Pyrex metering tube sealed to the body of the unit on adapter plugs. These plugs must be machined accurately for proper fit and must maintain good dimensional stability and firm seating in constant use.

Penton resists thread damage

According to the company, stainless steel tends to seize, gall, and gradually wear when continually threaded. It may also chip or break the Pyrex metering tube. Plugs machined from TFE (Teflon) resin solve the galling and breakage problems, but the threads on the relatively soft plastic are subject to damage on assembly. In addition, Teflon plugs creep slightly under pressure in assembly.

The Penton plugs, machined from bar stock from The Polymer Corp. of Pa., Reading, Pa., thread easily, seat firmly, resist shearing and deformation, and maintain a full seal.—End



PENTON PLUGS are tough enough to withstand continual re-threading into rotameter housing, have dimensional stability to assure tight seal for Pyrex metering tube (left).

Announcing another fiber glass first from Johns-Manville

Garanmat — a new mat produced from

A **DISTINGUISHED LINE** of products for the reinforced plastics industry was started in 1949 with the introduction of the Garan finish for fiber glass fabric. Next came Garan roving in 1952. In 1955 it was Garan woven roving (our good customers do the weaving). These developments proved to be big advances toward the improvement of the reinforced plastics industry.

A**ND NOW** Johns-Manville proudly announces new Garanmat, a clean, white chopped-strand mat produced from Garan roving. Garanmat is another addition to J-M's line of high-quality reinforcing materials for plastics.

Plastics, chemicals —and GATT

International negotiations will take place early next year under the General Agreement on Tariffs and Trade. The tenor of these negotiations, and the potential results, are of vital interest to every phase of the plastics industry

The revolution in international trade that began in 1947 when—at the behest of the United States—bilateral tariff, quota, and trade negotiations were replaced by round-table multilateral negotiations through the formation of GATT (General Agreement on Tariffs and Trade), will early next year move into a new phase, the direction of which will result from the negotiations to be conducted at the GATT meeting in Geneva, Switzerland.

The new tariff levels established there will affect literally every segment of the plastics industries all over the world but, particularly, the plastics industries in the United States, which are the largest makers and consumers of these materials. Those policies will also affect the future plans of makers of end-use products containing plastics components.

What makes the present meeting of GATT different from previous tariff discussions is that out of multilateral negotiations and through political and economic pressures have been formed the "blocs." There are two of these in Europe at present. One is the E.E.C. (European Economic Community), also known as the "Common Market." It consists of France, West Germany, Italy, Belgium, The Netherlands, and Luxemburg, and presently has a population of 170 million.

Common external tariff proposed

The E.E.C., by the Rome Treaty of 1957, is pledged to eliminate, by staged intervals, internal tariff and quota controls among and between its members. It also proposes to adopt a common, external tariff for imports from nonmember countries, including the United States. This common external tariff for each product is planned to be the average of member country rates in effect in 1958. For example, in 1958 France had a tariff on phonograph records of 25%, West Germany, 9%; Italy, 20%; and Benelux, 12 percent. Thus, under present policy, the new E.E.C. tariff on phonograph records would be approximately 17%, as compared to U. S. external tariff on phonograph records of 12½%, according to the Trade Relations Council of the U. S.

The other bloc is the E.F.T.A. (European Free Trade Association) or "Outer 7," comprising the United Kingdom, Norway, Sweden, Denmark, Portugal, Austria, and Switzerland. This bloc also proposes the gradual reduction of tariffs between its members and last July 1, cut same by 20 percent. There is no clear picture of the E.F.T.A. emerging policies concerning external tariffs.

Both these blocs claim a desire for keeping the paths of trade open, rather than operating on protectionist tendencies.

During recent months, and especially in the period of the meeting of the U. N. General Assembly, many private conversations were held pertinent to the establishment of other blocs, the Near East, Latin America, and New Africa being cases in point.

Overseas facilities planned

Three things are happening. First, the U. S. industry has been and will continue to be establishing plastics raw material plants abroad, by cooperative capital venture in lands within and without the blocs. General John E. Hull, president of M.C.A., recently stated that a survey of 50 U. S. chemical firms showed that 67% planned to establish overseas facilities in 1961, and expected to increase this to 77% in the next five years. Second, these raw material makers abroad will most possibly be producing in excess of local needs and will be exporting. Third, plastics processors abroad will be manufacturing plastics products, often under conditions of quite low comparative labor costs, for export—as in the case of buttons and raincoats discussed in our September Editorial.

The picture is complicated further by politics and by labor pressure in this country. A recent survey reveals that a majority of industrial workers in the U. S. are in favor of import restrictions and tariff legislation as a protection to their jobs.

There are many pressures involved at the GATT meeting. The U. S. is asking foreign countries to reduce certain tariffs in exchange for reduction of U. S. external tariffs to the countries and blocs involved. Some new members will be invited to join GATT, such as Spain, Tunisia, and Israel. The **(To page 190)**

CYMEL® MELAMINE

BEETLE® UREA

PLASTICS

REMEMBERED FOR PERFORMANCE – CYANAMID MOLDING COMPOUNDS

CYMEL 3135–3136 (glass-filled) Additional distinctive properties: outstanding electrical properties; high impact resistance; extraordinary flame resistance; good dimensional stability. Typical applications: circuit breaker boxes; terminal strips; connectors; coil forms; stand-off insulators. Specifications: Cymel 3135 (MMI-30, MIL-M-14E, Federal L-M-181 Type 8; ASTM D704-55T Type 8); Cymel 3136 (MIL-M-19061, MMI-5).

CYMEL 592 (asbestos-filled) Additional distinctive properties: resistance to atmospheric extremes; high dielectric strength. Typical applications: connector plugs; terminal blocks; a/c, automotive and heavy duty industrial ignition parts. Specifications: MIL-M-14E MME; Federal L-M-181 Type 2; ASTM D704-55T Type 2, SP1 SPEC NO. 27025.

CYMEL 1077 (alpha cellulose-filled) Additional distinctive properties: Surface hardness, heat resistance, unlimited color range. Typical applications: appliance housings, shaver housings, business machine keys. Specifications: MIL-M-14E – Type CMG (in approved colors); Federal L-M-181 Type 1; ASTM D704-55T Type 1, SP1 SPEC NO. 30026.

CYMEL 1500 (wood flour-filled)–CYMEL 1502 (alpha cellulose-filled) Additional distinctive properties: Good insert retention. Typical applications: meter blocks, ignition parts, terminal strips. Specifications: Cymel 1500 (MIL-M-14E Type CMG, Federal L-M-181 Type 6, ASTM D704-55T Type 6); Cymel 1502 (MIL-M-14E Type CMG, Federal L-M-181 Type 7; ASTM D704-55T Type 7.

BEETLE® UREA (alpha-filled) Additional distinctive properties: Economy of fabrication, economy of material, myriad translucent and opaque colors. Typical applications: wiring devices, home circuit breakers, tube bases, appliance housings. Specifications: Federal L-P-406A, LC 726-1, ASTM D705-55, Grade 1 (Arc resistance limits are in process of revision by ASTM), SP1 SPEC NO. 27026.

WRITE FOR COMPLETE TECHNICAL DATA.

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Special report from abroad:

The macroPlastic exhibition

Utrecht, Holland *Oct. 19-26, 1960*

Although not the largest exhibit of plastics materials, processing equipment, and applications ever held, the macroPlastic show (Utrecht, Holland, Oct. 19-26) was one of the most significant. Its locale was easy to reach from all major countries; its facilities were large, high, and light, providing plenty of viewing space; its timing made for low transportation and hotel rates; food and drink and lounge services were excellent; all Dutchmen speak at least three languages; and the show was most professional.

Coming between the last U. S., British, and German shows, and the 1961 U. S. and British shows, macroPlastic offered a chance to study interim progress in plastics in Europe. New developments were not many, but those shown were significant, especially to American industry. Technique refinements were frequent, leading always toward automation.

Materials

In materials, Europe is expanding its vinyl economy with emphasis on the rigids, the high-impact vinyls (alloys and copolymers) and the rigid foams. C.W.H. (Huls Chemical Works) in Marl in the Ruhr, making vinyl from acetylene, showed a plastics building in which floors, doors, stair treads, handrails, piping, and illuminated ceiling were vinyl. They had a door made of rigid vinyl foam, sandwiched between high-impact vinyl sheets, the door-frame being a fabricated profile of rigid material. They also showed a wall panel made by glueing two vacuum formed, thin, rigid vinyl sheets together as a core for two reinforced polyester skins. Their vinyl foam is relatively easy to make to controlled densities by a casting and heat-cure method, but to date is limited to single sheet production: work continues on development of continuous rigid-vinyl foam sheet for the building field. One of the Huls technicians commented that tunnel annealing has been a help in making superior strain-free and high-impact vinyl products.

Farbwerke Hoechst AG, Frankfurt, West Germany, also stressed rigid vinyls, especially a material containing chlorinated polyethylene, called Hostalit C and particularly for continuously extruded corrugated roofing and wall panels. These compete favorably with polyester panels in Europe. An article on this material will appear in a forthcoming issue of Modern Plastics.

From the standpoint of rapid development, the second most-exciting material in Europe is caprolactam nylon-6. A.K.U. (Algemene Kunstzijde Unie, N.V.), Arnhem, Holland, and Farbenfabriken Bayer A.G., Leverkusen, West Germany, are concentrating a lot of effort on achieving a variety of viscosities and even alloys for different applications such as film, filament, and molding. Main items in caprolactam nylon shown were hardware, moldings, machine parts and big pieces centrifugally cast from an extruder.

Polypropylene doesn't seem to have created as much excitement in Europe as in the United States, judging from the show. Huls is making it in Germany, Montecatini in Italy, and a combination of Shell and Dow will make it in Holland. Applications in Europe so far seem to be mostly in molded hospital wares and in filaments.

High-density polyethylene, likewise, was not impressively represented, although Hoechst had on display beer cases and milk-bottle cases molded from it. Apparently they stand up well, although costing twice as much as wooden cases. This material is also going into piping by the use of a special post-extrusion orientation process in which air pressure expands the pipe while take-off equipment stretches it lengthwise, achieving biaxial orientation. (see "Why biaxially oriented pipe," MPl, Nov. 1960, p. 111.)

In the styrenes the only news from Europe is that ABS polymers (acrylonitrile - butadiene - styrene) are coming into major production as molding materials. They are not expected to gain much headway against the vinyls in pipe. Bayer is quite excited about their possibilities in housings.

Modern Plastics' representatives were queried about American markets for polycarbonates. The examples shown at macroPlastic were mainly developmental.

Acetal resin (Delrin) made a big splash at the show because Du Pont is putting up a plant in Holland. All examples shown have been previously reported in Modern Plastics.

In the thermosets, the polyesters in reinforced plastics products of all kinds were exhibited. Quality was excellent. The epoxies showed up in quantity, too, but apparently haven't hurt polyester markets, except for tooling. Reinforced plastics are doing so well in Europe that U. S. Polymeric Chemicals Inc. has built a prepreg plant in Utrecht; Ferro is putting in a glass mat facility.

Of the styrene foams, recently so exciting in America, little was seen at the show. Urethane foams were exhibited in quantity, but none shown involved new uses or processing techniques. The same condition held for acrylics, cellulosics, melamines, ureas, and phenolics.

Machinery

New machinery developments were fairly few, but most significant.

Because of a) a paucity of English literature on the stands, b) a lack of original photographs available, and c) in many cases the presence of only Dutch sales representatives, Modern Plastics will present more detailed information in early subsequent issues. The more outstanding new equipment is reviewed in brief:

1. The first 1-to-5 color extruder for blow molding was offered by Blow-O-Matic Corp. Ltd., through its agents, Danish Plastics, Copenhagen, Denmark. In one operation this machine extrudes and blows up to five colors with an output of from 1 to 35 kilograms (2.2 to 77 lb.) per hour, based on low-density polyethylene. Drive is fully variable and a tube up to 6 in. in diameter may be made. A 5-color blown bottle is a thing to behold and should give packaging people ideas. Rainville Co. is the American agent.

2. A new line of blow molding equipment was offered by European Plastic Machinery, A.B., Malmoe, Sweden. Called Euromatic, this

equipment, available in single-mold, double-mold, or triple-mold models, is said to handle bottle sizes from the smallest to 1-gal., depending on the model, with no finishing operation required. Multiple units can be arranged in series with control boards grouped so one operator can run six or eight machines.

3. **The new Reifenhäuser 4½-in. extruder,** equipped for sheet (rigid vinyl, impact styrene or ABS) production, received much attention. Available with L/D ratios of 20 or 25:1, vented or non-vented, and with resistance heating with air-water spray cooling. The new modular construction allows easy reach of all internal parts, including a swing-out, inline drive motor, to conserve press space.

4. **Another version of this extruder,** with special take-off equipment, is used for making the corrugated high-impact vinyl building materials mentioned earlier. A complete story on this equipment will run in an early issue of MODERN PLASTICS. Reifenhäuser is probably the biggest manufacturer, and one of the most advanced, of extruder and take-off equipment in Europe. Delivery time to United States: 5 to 6 months on this big equipment. For at least two makers of injection molding equipment, one U. S. and one European, Reifenhäuser is building pilot screw preplasticators.

5. **The J.u.W. Müller G.m.b.H. series** of new extruders, coordinated and synchronized with the company's specialized caterpillar take-off equipment, features stock screws with L/D ratios of 18 to 24, and is said to be good for making of vinyl floor tile and thick cables.

6. **Still on extruders,** Jumex, Brussels, Belgium, featured a multiple-screw machine with 4 screws, claimed to operate with either powder or pellet feed to give superior blending in colored and filled materials. Jumex also featured a new device for stretching and spooling thin polyethylene bags.

7. **One of the important announcements** in the injection molding machine field was the new 2500-ton Triulzi from Milan, Italy. It handles 425 oz. per shot, based on polystyrene, and is recommended for molding complete refrigerator interiors, large tubs, and shipping containers. It is so big and new that Triulzi didn't show it, except in photographs. Full details will be forthcoming soon.

8. **Turner Machinery Ltd.,** Bramley, England, offered a new rotary injection molding machine, the Turnamatic. It plasticates 66 lb./hr., has four molding stations, and will mold 11.8 cu. in. of material per shot. It may be used non-rotary if required.

9. **A new "baby" extruder-injector** was presented by Ste. Lumeca, Paris, France. A tiny and tidy device, it molds no sprue, shoots 25 shots/min. up to a maximum of 10 g./shot. At the show it was making small caps at high speeds.

10. **Hupfield Bros. Ltd.,** London, England, showed a new ¾-oz. capacity injection machine with side injection and vertical lock, especially suitable for parts requiring inserts. Speeds of 3½ sec./cycle are normal on insert work.

11. **Neither a compression nor an injection press** is the new Duroplast machine made by Georg Seidl K.G., Munich, West Germany. It molds thermoset premixes such as polyester-glass and phenolic-nylon by the use of a ram pumping into from 2- to 6-mold stations each of which eject a molded part every 20 to 25 seconds. Material is fed horizontally into the vertical-acting press sections. Makers recommend it for filled and/or reinforced thermoset electrical parts, even with inserts.

12. **With an eye to the** multiple-press, single operator, automated production of small auto-electric and similar parts, the B.I.P. Engineering Ltd., Sutton, Coldfield, England, presented the new Bipel 20-ton automatic compression press. This unit has a stripper plate attached to the front of the loader, so both move together, making ejection and refill most easy. The new Bipel has a sequenced cycle with the addition of a "breather" for these types of materials.

13. **An interesting new line of spray-up equipment** is produced by Aust & Schüttler u. Co., Düsseldorf, West Germany, based on a process developed by H. Hanusch. The machines, known as M.A.S. guns, come in three types: a stationary unit for large molded parts, a portable unit for tank lining and small-space work and a machine for construction maintenance. In addition, A & S makes a device for testing laminate porosity and a mixing and metering device for filled resins. All devices work with both epoxies and polyesters and with almost any kind of fillers.

14. **Big parts, pipe coating and other effects** produced by the Engel process were shown by Schulte-Ultex, Düsseldorf, West Germany. One of its newest offerings is a line of low-pressure, large-platen presses for making sandwich panels with foam or honeycomb cores.

15. **In the accessory equipment field** the SPS semi-automatic screen-printing machines attracted much attention. The use of a vacuum to get absolute register, and the large platen areas (up to 33 by 46 in.) caused the interest. A number of one-man printers are in the series. They are made by Siebdruckgeräte von Holzschuher K.G., Wuppertal-Oberbarmen, Germany.

16. **Another line of printing and decorating** equipment is the Milford-Astor Ltd. dry printing machines sold in the United States by Rainville Corp. The range of these units provides for printing on flat sheets, tubes, all shapes of moldings, and thermoformed pieces. They can be attached to automatic presses and adjusted for speeds up to 4000 per hour, single or multi-color, with the use of a tape medium.

17. **A new mixing and kneading machine** for small quantity batches —up to 2 gal.—was announced by Fritz Meili, Zurich, Switzerland. In two connected half-cylinders, two kneading arms rotate in opposite directions and at different speeds. Units are available with heat and cooling connections.

18. **A big-scale cyclone mixer line** for dry materials was shown by Nautamix N.V., Haarlem, Holland. They feature high speed with low power consumption and allow for addition to mix of liquids through a metered jet device.

19. **Rotojet multi-station, rotary mold** injection machines received much attention. They are designed for the rapid production of small parts such as cups and closures. Made by C. S. B. of Lyon, France, and distributed in the U. S. by the Conopac Corp., New York, N. Y., a Model T.5 machine, an eight-station model, was on display. Molds up to about 2½ in. in diameter can be handled and are clamped with about 660-lb. force. Machine operates at rates up to 50 injection cycles/min., and delivers up to 11,500 p.s.i. injection pressure. Rotation of multiple molds allows successive injections without waiting for part to cool.

20. **A wide range of injection machines** by R. H. Windsor Ltd., London, England, were also on display. Impressive was the AP 200, which featured the company's two-stage, twin-screw Autoplas plasticating equipment. With a shot capacity of 124 oz., it is capable of preplasticating 350 lb. of polystyrene per hour, and has an 800-ton clamp force. Plunger speed is 325 in./min. on a 17-in. stroke. Another machine available from Windsor is the fully automatic AP 16 with reciprocating preplasticating screw. Shot capacity is 14 oz. and clamp force is 175 tons.

21. **Screw preplasticating machines** made by G.B.F., Milan, **(To page 192)**

Special report:

New England S.P.I. meeting

Oct. 12-14, Wentworth-by-the-Sea, N. H.

The "Soaring Sixties," rather than being a wishful advertising slogan, may indeed become one of the most successful decades for plastics —provided the industry can rise to meet the challenges that the next 10 years will bring. This note of combined optimism and warning was struck by all the speakers at the recently concluded 16th annual meeting of the New England section of S.P.I., held at Wentworth-by-the-Sea, N. H., Oct. 12-14, 1960. With a registration of 415, this was the largest such meeting that has ever been held by the section.

Plastics' strong position

The main arguments for plastics' expected progress in the Sixties is their favorable price-volume position vis-a-vis such materials as steel, wood, glass, aluminum, copper, zinc, brass, etc. James Turnbull (DeBell & Richardson Inc.) in his talk on "Today's Big-Volume Plastics in Tomorrow's Markets" predicted a gradual and steady decline in price of polystyrene, PVC, and the polyolefins to a definite resistance level, around which the price would fluctuate but below which it would not go. These levels are (the ranges indicate various formulations):

PVC	17 to 18¢/lb.
PE	22 to 25
Polystyrene	18 to 24

At these levels, end-user industries should find plastics a decided asset in holding their price lines—and volume growth should increase accordingly. Unfortunately, there is a considerable time lag between the realization of these economic facts of life and their application in product design. For example, Detroit is today already writing material specs for the 1963 car. Similar conditions prevail in other industries.

What does this mean for the plastics industry? It suggests that the material supplier will have tough sledding till about 1963, after which new mass markets should be firmly established.

It is significant that this price situation coincides with a decade that, by 1970, will see a population of over 200 million and a gross national product of $750 billion. By that time, plastics production is estimated at an annual rate of 12 billion lb., or 6 million tons.

Where will this production go? The three most promising markets, according to A. R. Marusi, president of The Borden Chemical Co., in his keynote address "The Fabulous 60's —Fact or Fiction?" are packaging, household appliances, and building.

Packaging: Despite impressive performance, plastics have barely scratched the surface. Within five years, plastics usage could triple.

Appliances: Just as an example, refrigerators use about 2 million tons (40 million lb.) of plastics. With new design concepts, this could quite conceivably go to 10 million tons (a five-fold increase). Similar growth can be expected in other appliances.

Building construction: Currently a $50-billion industry, this market has seen a penetration by plastics of roughly 2 percent. If economic conditions would lead to just a 10 percent penetration of this market, the value of plastics used would exceed the total value of the plastics processing industry today.

In all three industries—packaging, appliances, and construction—the time lag described by Mr. Turnbull exists. In addition, building codes, FDA regulations, Underwriters' Lab Standards, all present challenges. Various S.P.I. committees are actively engaged in coping with them.

In addition to these problems, the threat to the processor from imported finished goods looms large. As reported by William T. Cruse, Executive V.P. of S.P.I., this foreign competition is fierce indeed and, because of the lower labor cost, cannot be successfully met through the normal interplay of economic force. Here are three examples he cited:

Item: A fleece-lined vinyl snow boot was made in California to retail at $6.00. An equivalent boot was imported from Japan to retail at $2.98, less than the wholesale price of this American-made boot.

Item: Bubble pipes molded here sold for 60¢/doz. Japanese imports of similar quality sold for 23¢/doz.

Item: An assemble-it-yourself skeleton, molded in the United States, sold for $4.00. A Hong Kong import, exactly duplicated the American unit, at 79 cents!

In all three cases, American production was discontinued.

What to do? Revision of tariff laws seems imperative. However, according to Mr. Marusi, there should be no across-the-board tariff. Instead, he suggested a fact-finding board that would note any distress areas, make rapid appraisals, and quick decisions.

A call to all processors to report to the S.P.I. cases such as cited above was made. The S.P.I. will forward any such material to our negotiating teams in Geneva, where tariff problems are now being dealt with (See our report, p. 98).

Meeting the profit squeeze

While large increases in plastics consumption seem certain, the profit squeeze on the processor is becoming a real problem. Since 1949, profit margins for plastics processors have dropped 20% according to John J. O'Connell of Consolidated Molded Products Corp. A drop of about 12% took place in the past year alone. In his paper, "Meeting the Profit Squeeze in the 60's," he pointed out that net profits of processors are running at approximately 2.5 percent.

As a result, they are undercapitalized, have antiquated machinery, do not conduct sufficient research, operate on outmoded production systems. Making the situation worse is the fact that the molder must tie up his capital in his customer's mold, without the customer making any contribution prior to delivery of the final tool. In fact, the molder even pays for the insurance on his customer's mold.

The profit squeeze must be attacked along several lines:

1. Machine makers should develop a uniform range of machine sizes. They should incorporate really new features in their new machines, not just give them a superficial face lifting. Special efforts should be directed toward full automation, based on data processing techniques. Also helpful would be the development of sound equipment-leasing plans.

2. Materials **(To page 181)**

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flexibility of

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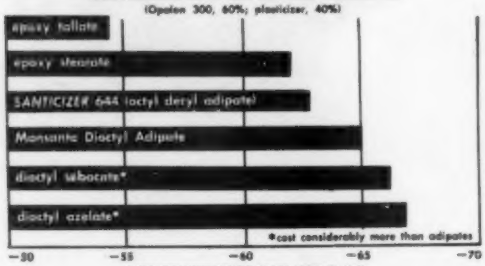

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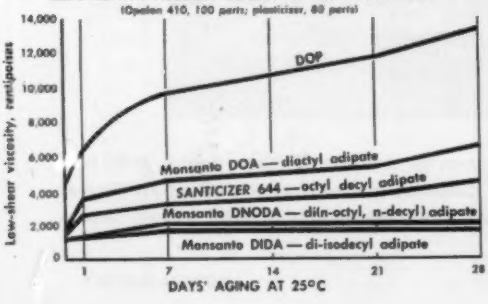

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- ☐ Samples of Monsanto Adipates for Testing

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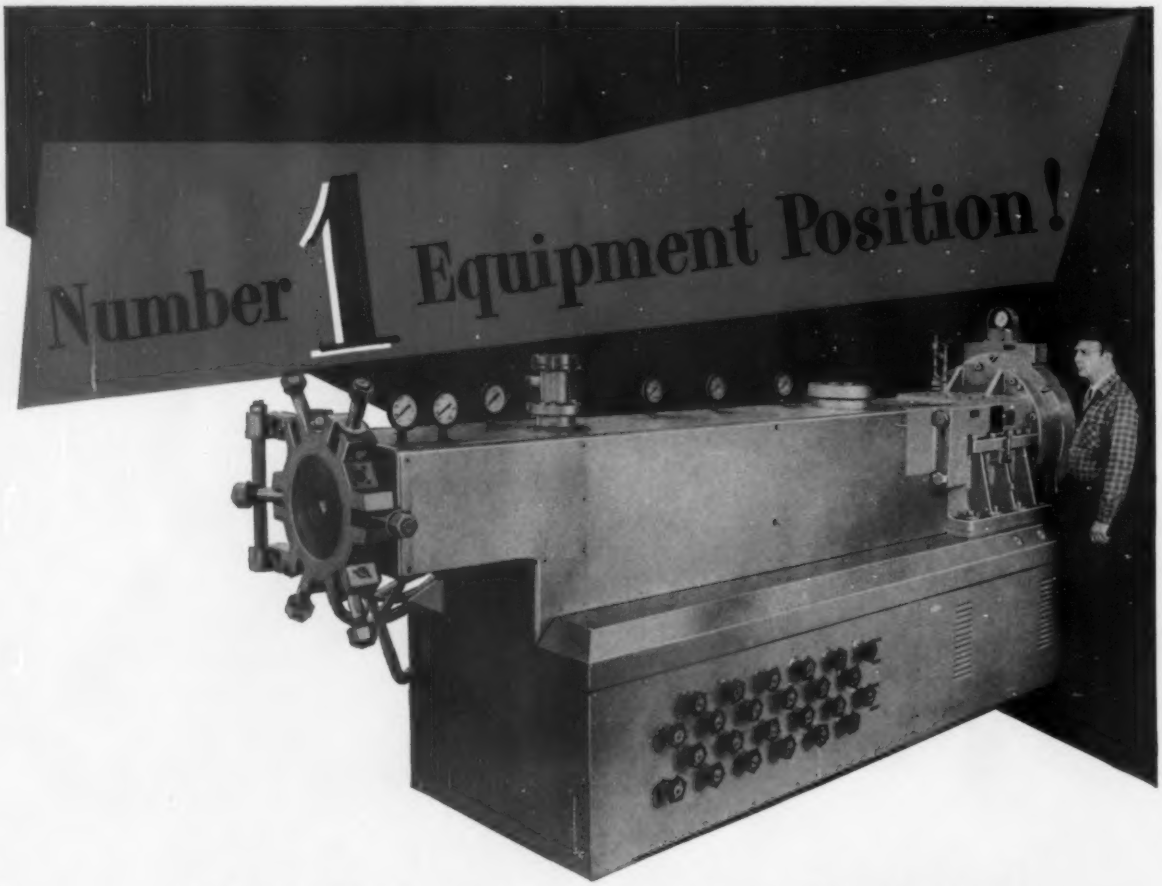

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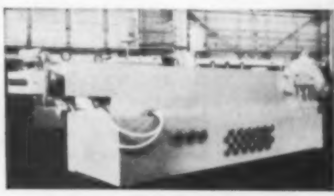

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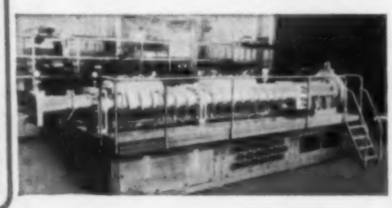

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Breakthrough in mold-making— ELECTRO-EROSION

New high-precision electrical discharge machines cut mold cavities of high quality in hardened steel

By Frank Jaques† and Joseph Schmidt‡

Electro-erosion, or electrical discharge machining, is a process which has been used in this and other countries in various forms for a considerable number of years, but which has only begun to be exploited by the plastics industry in recent years. The first electrical discharge machines offered in this country were sold for such applications as "tap busting," that is, the disintegration of taps and drills, or hardened pins and studs which had broken off and were still embedded in the work. For this type of work, the machines were crude, resembling a low-priced drill press.

Within the past few years, intensive development work by the machine builders has resulted in highly improved machines being brought to market. Today four companies are known to be offering machines for precision tool and die work in the U. S. A. They are: The Charmilles Engineering Works Ltd. (Geneva, Switzerland), The Cincinnati Milling Machine Co. (Cincinnati, Ohio), The Elox Corp. of Michigan (Troy, Mich.), and the Matson Co. (Detroit, Mich.). Typical of these machines is the Charmilles Eleroda D1 shown in Fig. 1, below.

Without any noticeable amount of fanfare, an increasing number of electro-erosion machines are showing up in plastic processors' and mold and die makers' toolrooms. In these shops they are being used to produce molds and dies of highly complex design and at levels of quality extremely difficult to achieve by conventional metal-cutting methods. Most of the engineers who have used

FIG. 1: Charmilles Eleroda D1 electro-erosion metal-cutting machine showing electrical arc controls and hydraulic electrode-advancing system (at bellows). →

FIG. 2: Close-up of the electro-erosion metal-cutting machine, showing a work piece clamped at the bottom of the trough-table, which is filled with a dielectric oil during the cutting process. Electrodes are held in place by "magnetic chuck."

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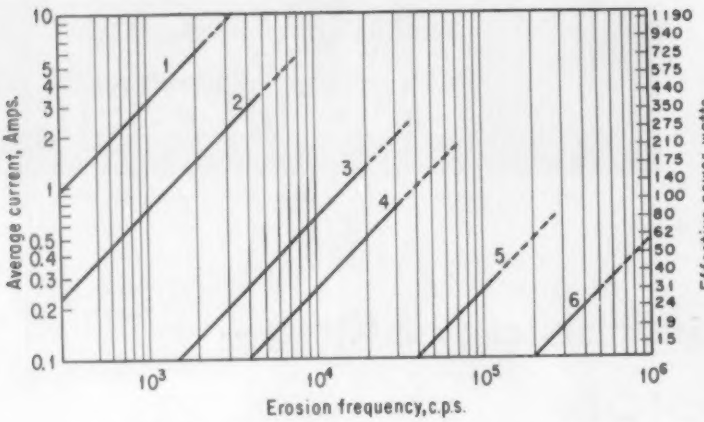


FIG. 3: Graph showing relationship between current and frequency of the erosion arc for six settings on the Charmilles machine shown in Fig. 1. Roughing cuts are described by curves 1 and 2, intermediate cuts by 3 and 4, and finishing cuts by curves 5 and six.

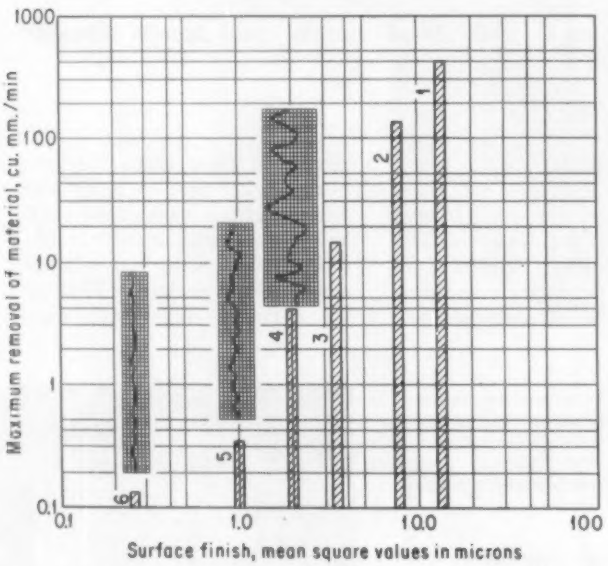
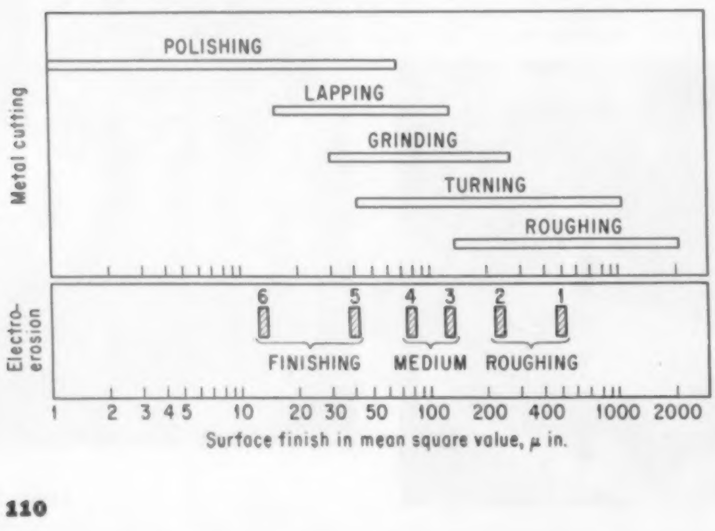


FIG. 4: Diagram showing the rate of material removal for the six settings referred to in Fig. 3. Sketches above Bars 4, 5, and 6 show the relative roughness of the surface finishes. Data is for a copper electrode cutting hardened tool steel with Rockwell Hardness of 60 on C scale.



electrical discharge techniques are quick to agree that electro-erosion is truly a major technical breakthrough in the manufacture of plastics molds. This article is intended to give the reader an introduction to the subject and point out how this new tool offers many advantages in the construction of molds and extrusion dies.

How it works

Almost everyone is familiar with the "pitting" of metal contacts which takes place when an accidental electrical discharge, or arc-over, occurs in an electrical relay or switch when it is opened or closed. Although this arcing is highly undesirable in electrical switchgear, the ability of an electrical arc to burn or "pit" metal is the heart of an electrical discharge cutting machine.

In this machine, the blank metal work piece is made one of two electrodes between which the electric arc is struck. The work piece is usually at the negative or ground potential. The other, or positive electrode, which has a cross-section of almost exactly the same size and shape as that of the hole to be cut, is placed perpendicular to, and above, the metal blank to be cut. This electrode is brought close to the work piece which is fixed on a stationary, precision set-up table at the bottom of a trough as shown in Fig. 2, p. 109, which is then filled with a special dielectric oil. The oil serves two purposes; it insures uniform arcing over the two surfaces of the electrodes and, by its forced circulation in the work area, it removes the debris from the work area.

At this point the operator sets the controls on the machine in accordance with the type of cut and finish desired and the type of arc action necessary to give the required cut and finish. In electro-erosion machining there are generally two cuts made to cut a cavity: roughing and finishing.

Roughing can either be done by conventional methods or by elec-

FIG. 5: Diagram comparing the surface finishes produced at various settings on the electro-erosion machine with surfaces produced by various conventional metal-working techniques.

tro-erosion, depending on which appears more appropriate for the specific job at hand. A simple round hole is probably more easily done by drilling whereas a thin, narrow, sharp-cornered rectangular slot is more easily roughed out using electro-erosion. The latter is more easily done by electro-erosion because of the delicate and fragile cutters which would have to be used in conventional cutting machines and use of which could easily result in excessive tool breakage as well as poor precision.

When electro-erosion is used for roughing, one naturally wants to remove metal at the maximum possible rate; surface quality is not important in view of the finishing operation to follow. Figures 3 and 4, both on p. 110, describe the relationships between arc power, current, and frequency and the corresponding metal removal rates and finishes available in the Charmilles machine shown in Fig. 1.

In roughing, a high-current, low-frequency, high-power arc is used to obtain the maximum metal removal rate. This intense heavy arc has an effective power of about 1 kw. and results in a rough surface resembling a heavy stipple finish used in molds to imitate a leather surface. Sometimes this roughing cut is used as a final finish where an imitation leather surface is desired in the mold surface. This corresponds to a surface finish of about a 15 or 500 μin. (root mean square values) and a metal removal rate of about 400 cu. mm./min.

After roughing, finishing is done by using a low-current, high-frequency, low-power arc (See Fig. 3.) The finest finishes are obtained at powers of about 15 w., resulting in a surface finish of about 0.25 μ or about 10 to 12 μin. (root mean square values). The metal removal rate is correspondingly reduced in finishing and for the finest finish setting on the Charmilles machine is about 0.1 cu. mm./min. However, in finishing, the amount of metal to be removed is also considerably reduced and the time required to make a finishing cut relative to a roughing cut would not be directly proportional to the ratio of the metal removal rates that are shown above.

Once the settings are made on the machine, the cutting is entirely automatic. Circuits in the machine monitor the current and character of the arc and control the advance of the cutting electrode to keep the gap and arc conditions constant. The cutting action can be stopped automatically at any predetermined time at the end of a cut.

Mechanically, the process most closely resembles hobbing, in that electrodes on present-day machines move only in a vertical direction. It differs in that hardened steel can be cut and no pressure is required to sink the electrode. The cutting electrode used is similar to a hob; that is, its contoured face is "pressed" into the work producing a female impression of the male configuration on the face of the electrode. Machine design problems have thus far hindered the development of machines which can simultaneously cut along three axes. However, it is not inconceivable that such machines may be developed in the future.

An extremely significant feature of electro-erosion is the fact that the cutting electrode is never in mechanical contact with the work piece. Therefore, no mechanical pressure is ever exerted on either the cutting tool or the work and the distortion of either during the cutting process is practically impossible. This characteristic of electro-erosion is a major contributing factor to the precision of the machine, which can easily work to tolerances of ±0.0002 in. as compared with the ordinary machine tolerance of ±0.001 inches.

This lack of contact is due to the fact that the cross-section of cuts made by the electrode are always slightly larger than the cross-section of the electrode itself. The bulk of the arcing, taking place during a cut, is confined

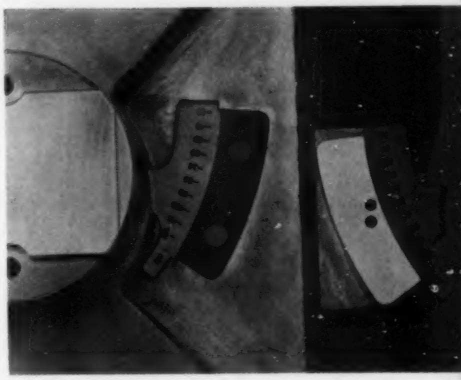


FIG. 6: Copper electrode shown at left of photo was used to simultaneously cut the cavity and raise the letters in the hardened mold at right. Note the high fidelity, smooth surface, and fine detail. Numbers are approximately 0.016 in. high.

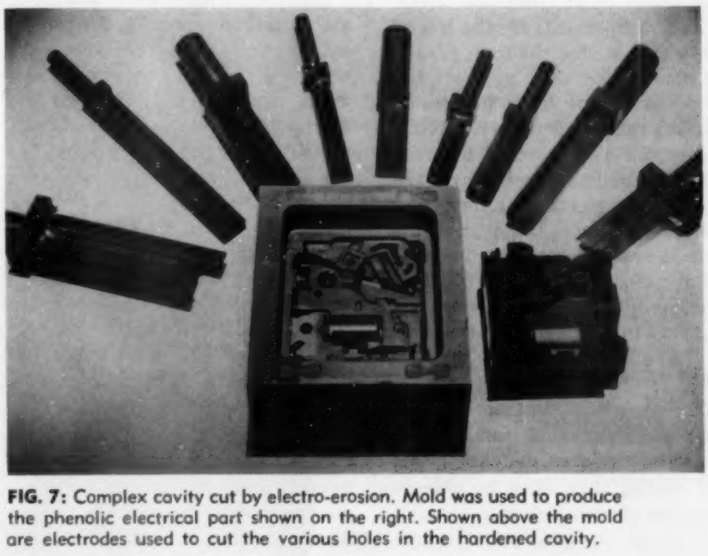


FIG. 7: Complex cavity cut by electro-erosion. Mold was used to produce the phenolic electrical part shown on the right. Shown above the mold are electrodes used to cut the various holes in the hardened cavity.

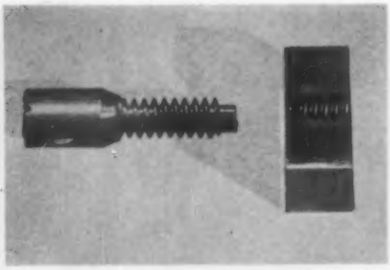


FIG. 8: Copper electrode and mold set for worm gear of toy train, which was cut with the electrode. Same electrode is used to cut matching half of the mold, insuring congruity of the mold edges on the parting line.

to the bottom advancing face of the electrode, and to a small distance up the vertical sides of the electrode. Except for this small area near the bottom face, essentially no arcing takes place on the vertical sides of the electrode. This is explained as follows: For a given power input, the ability to develop arcing between two electrodes depends on the size of the gap between the two electrodes. As this gap is increased in length one reaches a critical gap size (on the order of a few ten-thousandths of an inch and dependent on the power of the arc) above which arcing can no longer take place. As erosion of the arcing surfaces takes place, the gap between the arcing faces increases, due to the loss of material from the surfaces. As mentioned before, the positive electrode in the machine is advanced vertically down into the piece, which compensates for the loss of material at the bottom of the electrode and acts to keep the gap spacing constant, thus maintaining the arc. However, there is no lateral movement of the cutting electrode. Therefore, on the sides of the electrode, arcing continues only until the critical gap size is reached between the sides of the electrode and the walls of the cavity being eroded; here arcing and further erosion cease.

Materials

There is virtually no limit to the materials which can be used as electrodes or as the work piece. Of course, they must be able to conduct electric current.

Two of the most popular materials for electrodes used in cutting steel molds are copper and brass. Other metals have been used, but copper and brass have better cutting characteristics in working with mold steels and result in an optimum combination of cutting speed and surface finish. One must remember that both the cavity and the electrode are eroded by the process and the relative rates of erosion are also a consideration in the device of the electrode.

Other factors sometimes enter into the choice of an electrode material. An interesting example was the use of a finished profile extrusion of aluminum as an electrode to cut an extrusion die to replace the die which was used to produce the profile used as the electrode. In another case, the steel core of a mold was used as an electrode to cut a matching contour in the cavity side of a mold to produce a piece with a through hole in it. Using the core of the mold to cut the cavity produced exactly matching surfaces, which resulted in positively sealing off the contact area against mold flash.

Because of the growing interest in electro-erosion, special electrode materials are being developed for the process. For example, General Electric is now offering a graphite electrode formulation for evaluation in the process.

Cuts hard-to-cut metals

Turning to the type of materials which can be cut by the process, one is immediately impressed with the inclusion of materials which are extremely difficult to cut with conventional tools. Most significant to the mold maker is the ability of electro-erosion machines to sink cavities in hardened tool steels with Rockwell Hardnesses of 60 and above on the C scale. Cavities can even be cut in carbide blanks. In fact, any conductive metal can be cut on an electrical discharge machine and cut with the high precision indicated previously.

As implied above, the proper choice of the electrode material to cut a given metal or alloy will play a part in determining the maximum cutting rate and finish which can be achieved by the process. Copper and brass are now most widely used for cutting mold steels. However, as with any new technique, there is much experimentation going on to determine which electrode materials are best for various metals.

Use as a mold-making tool

Electro-erosion machines offer many advantages to the plastics mold maker. First is the higher quality mold which can be made using electrical discharge techniques. As mentioned before, the machine permits him to work to tight tolerances in the order of ± 0.0002 inch. In addition to the tighter tolerances, he can also cut cavities with surface finishes approaching that of a polished surface. For some molds the cavity requires no further finishing. For surfaces requiring polishes greater than 10 to 15 μin., the limit of the electrical discharge machine, additional hand polishing is required. However, the hand labor required for the polishing is reduced many-fold due to the initially better finish on the starting surface. A comparison of surface finishes obtained with conventional machining techniques and those available using electro-erosion is shown in Fig. 5, p. 110.

One of the greatest contributions to the quality of the molds is the fact that electro-erosion allows the mold maker to cut cavities in hardened tool steel. Since conventional cutting tools will not readily cut hardened steel, the usual mold-making methods require that the steel cavities essentially be finished prior to hardening. In the hardening process the mold maker runs the risk of losing the man-hours he has put into the mold if internal stresses in the steel cause the cavity to warp or distort. With hobbed cavities, internal stresses may be so large that they may even cause the mold to split or crack, resulting in a total loss. Even small distortions may cause the mold to go "out of tolerance."

With an electro-erosion machine, the mold maker can rough out his soft cavity using high-speed conventional cutting methods, send the rough blank to hardening, square up his hardened

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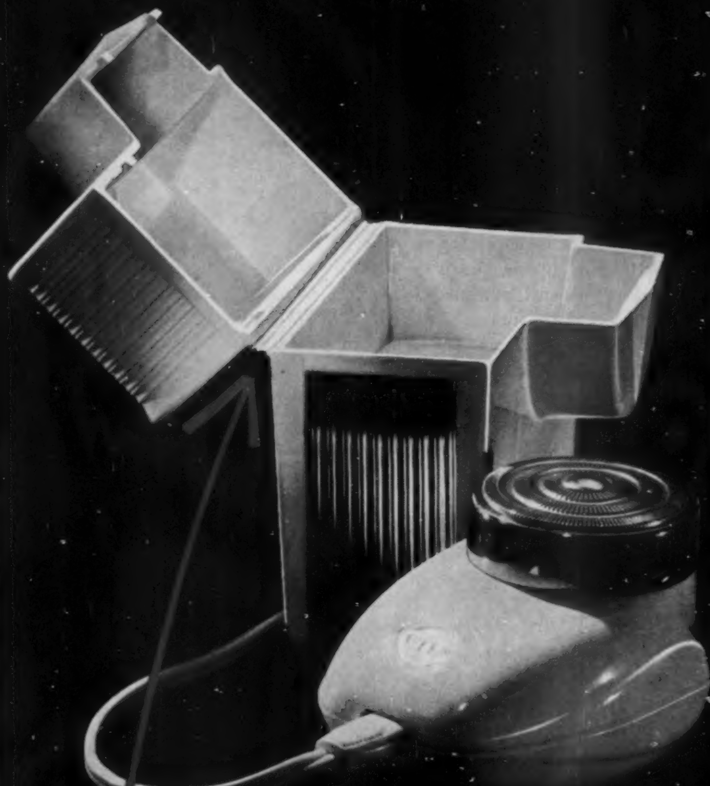

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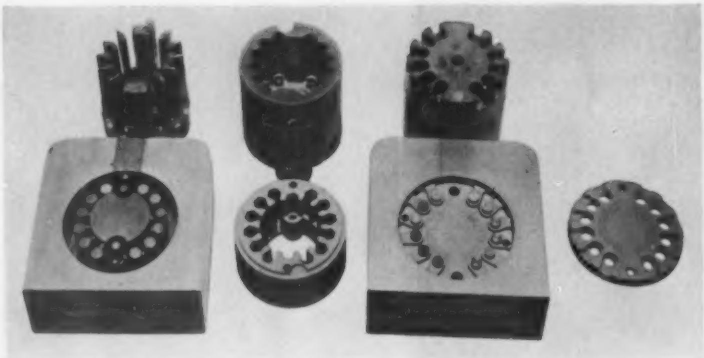

FIG. 9: Two molded plastic electrical connector parts shown with their molds, which were cut by the electrodes shown above the molds. Hexagonal pins in mold at left are not separate pins but were raised by two electrodes shown. Note clean sharp corners and details.

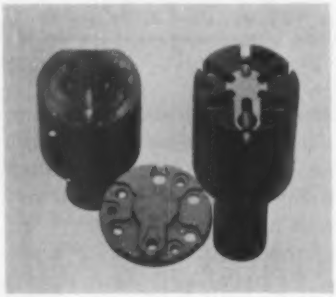

FIG. 10: Molded part and two copper electrodes used to cut mold to produce the part. Cavities can be cut in hardened steel to tolerances of ±0.0002 in. with finishes of 10 to 15 µinch.

blank, and then sink his finished cavity in the hardened steel to final dimensions and a fine finish; ready for any additional polishing which may be required. Since the number of man-hours spent in roughing out the cavity is minimal, any loss involved in spoilage of the cavity blank in the hardening process is considerably less than that which would be involved in the loss of a cavity closer to completion.

Another advantage arising out of the ability of the process to cut hardened steel is the ability to modify existing molds without the need for annealing the mold steel. If a change in design of a part requires the addition of a boss on the molded part, it is a simple matter to prepare an electrode with the cross-section of the required boss and sink it in the hardened steel where required. Likewise, if a female impression is required on the part, a cavity can be cut in the mold for the insertion of the new core to produce the female impression on the molded part. The savings in time, and the extension of the use of existing molds is, of course, obvious.

Since the process produces cavities in metals which are exact impressions of the electrodes used, the cutting of inside sharp corners is no problem. To illustrate the fidelity and sharpness of detail possible with the process, an electro-erosion machined mold face with raised figures (to make depressed figures in the part) is shown in Fig. 6, p. 111. Shown beside it is the copper electrode used to sink the cavity and raise the figures on the mold simultaneously. The numbers raised about 0.016 in. off the mold face and are $\frac{3}{32}$-in. type.

This ability of electro-erosion cutting to reproduce minute detail and sharp corners becomes tremendously important in the production of highly complex molds which would ordinarily have to be sectioned to develop the sharpness of details. Figure 7, p. 111, shows a mold used to produce the phenolic electrical parts shown next to it and some of the numerous electrodes used to sink the various cavities shown in the mold. With the exception of a few places where section inserts were a must, the entire cavity was electrically cut. Where sections were required, electro-erosion was used to cut the cavities for insertion of these sections into the cavity block.

Reduced sectioning also allows the molder to reap the benefits of electro-erosion. With a lesser number of crevices resulting from mold sectioning, there is less chance for material to creep into the crevices to distort or break delicate mold fins and cores. Although the reasons are not entirely clear, fins and cores raised in the mold by electro-erosions are also generally tougher than inserted fin and core sections. In the case of one mold for an electrical switch part, the breakage of delicate core pieces in the conventionally cut mold was a serious mold maintenance problem in the molder's plant. When the same cavity was duplicated by electro-erosion methods, core breakage from operation of the mold was entirely eliminated.

As mentioned before, no pressure is exerted on either the electrode or on the work and neither contact each other during the process. This makes it possible to use very thin, delicate electrodes to cut very thin and accurate slots with sharp corners in mold faces. In fact one can sink the edge of sheet brass or aluminum about 0.006 in. thick into hardened steel, using the sheet metal as an electrode.

In addition to the above operations, electro-erosion can do a much better job in the production of molds for the making of plastic parts with external threads. It is easy to cut helical screw threads on a lathe. However, when such threads must be cut into two halves of a mold to produce an external thread on a molded part, both the cutting and the matching of the two mold halves is a difficult problem using conventional cutting techniques. With electro-erosion the external thread desired on the part is simply cut into a copper electrode on a thread mill. The electrode is used to cut one side of the thread in one half of the mold and then rotated 180° and used to cut the other half of the mold, thus insuring that matching edges of the thread cavity will be exactly congruous along their entire length. (See Fig. 8, p. 112). The technical **(To page 196)**


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Predicting mold flow by electronic computer

By H. L. Toor*, R. L. Ballman†, and Leon Cooper‡

It is shown that the gross flow process which takes place when a molten polymer is forced into a cavity whose walls are held below the freezing point of the polymer may be predicted from the rheological and thermal properties of the polymer by simultaneously solving approximate forms of the energy equation and the equation of motion on a digital computer.

Steady flow of a liquid through a closed channel whose walls are held at a temperature below the freezing point of the liquid is possible only for channel lengths below a certain critical value. For lengths above this critical value, the skin solidifying at the walls will increase in thickness and ultimately fill the entire channel choking off the flow. The critical length will depend upon initial conditions. For example, a channel which at time zero is filled with frozen liquid at the wall temperature always has a critical length of zero. If a cold channel is initially empty and at time zero a liquid or polymer melt begins to flow into the channel or cavity, a steady-state process is possible only if the cavity length is less than the critical value and the cavity is open ended. If the cavity is longer than this critical length, flow can proceed for only a finite time, no steady state is possible (although the mean velocity may approach zero as time approaches infinity), and the maximum length of cavity that fills is the critical length.

Flows of the type discussed above occur in industrial processes such as injection molding and die casting as well as in nature, and the object of this work is to devise a method of calculating the mean velocity in a cold cavity as it is being filled, in order to obtain the critical length or "fill out" and the time necessary to fill the cavity to any length.

The system under consideration is shown schematically in Fig. 1, p. 118. (For nomenclature, see Table I, below.) At time zero the constant pressure P'_r is applied to the hot fluid in the isothermal reservoir and fluid is forced into the cavity whose walls are at a constant temperature T_D. T_D is low enough so that fluid at this temperature is essentially frozen. At subsequent times the wave front has moved a Distance X into the cavity. The problem is, given the system properties, to predict the relationships among V, X, and time. One relationship is known:

$$V = \frac{dX}{d\theta} \qquad \text{Eq. 1}$$

It has been shown (1), (2), (3)[1] that, in a cold, wide, rectangular cavity which is filling with hot polymer, the velocity decreases exponentially with time under very general conditions while, if the flow were isothermal, the velocity would decrease with time along a hyperbolic curve and at a much slower rate.

Clearly the interaction between the heat transfer from the melt to the cold wall and flow must be included in any description of the process. This is equivalent to evaluating the resistance in the

[1]Numbers in parentheses refer to literature cited at the end of the article, p. 209.

*Carnegie Institute of Technology, Pittsburgh, Pa. †Monsanto Chemical Co. Springfield, Mass. ‡Monsanto Chemical Co., St. Louis, Mo.

From a paper read at the MacroPlastic Internationale Kunststoffenbeurs, Amsterdam, Holland, Oct. 17-19, 1960. Complete Proceedings of this Congress will be published by 't Raedthuys, N. V., Tesselschadestraat 5, Amsterdam-W. Holland, at D. Gids. 25 ($6.75) per copy.

Table I: List of symbols

Symbol		Definition
A	=	temperature dependent rheological parameter, $\frac{1}{\text{sec.}}\left(\frac{\text{sq. in.}}{\text{lb.}_F}\right)^n$.
A°	=	rheological parameter, $\frac{1}{\text{sec.}}\left(\frac{\text{sq. in.}}{\text{lb.}_F}\right)^n$.
b	=	rheological parameter, °F.
B	=	reciprocal fractional rate of velocity decrease, sec.
c_p	=	heat capacity, B.t.u./ (lb.$_m$) (°F).
F	=	functional symbol.
k	=	thermal conductivity, B.t.u./ (sec.) (in.) (°F).
n	=	rheological parameter.
P	=	pressure, p.s.i.
P_o	=	pressure at cavity entrance, p.s.i.
P'_r	=	pressure applied to fluid, p.s.i.
R	=	cavity half width, in.
T	=	temperature, °F.
T°	=	rheological parameter, °F.
T_C	=	reservoir temperature, °F.
T_D	=	cavity wall temperature, °F.
u	=	axial velocity, in./sec.
v	=	radial velocity, in./sec.
V	=	mean velocity, in./sec.
V_o	=	velocity at time zero.
x	=	axial distance coordinate, in.
X	=	length of filled cavity, in.
X_f	=	fill-out, in.
y	=	distance from center of cavity, in.
ε	=	coefficient of thermal expansion, $\left(\frac{1}{°F}\right)\frac{\text{B.t.u.}}{(\text{in.-lb.}_F)}$
θ	=	time, sec.
θ'	=	time as defined by Eq. 7, sec.
ρ	=	density, $\frac{\text{lb.}_m}{\text{cu. in.}}$
τ	=	shear stress, $\frac{(\text{lb.}_F)}{(\text{sq. in.})}$
ϕ	=	volumetric rate of frictional heat generation, $\frac{\text{B.t.u.}}{(\text{sec.})\ (\text{cu. in.})}$
i	=	increment number.

Table II: Physical properties of polystyrene[a]

$$A(T) = A^{o}\,(e) - \frac{b}{T - T^{o}}$$

$$A^{o} = 111.5\ (\text{sec.})^{-1}\,\frac{(\text{sq. in.})_{n}}{\text{lb.}_{f}}$$

$$b = 1203\ ^{\circ}\text{F.}$$

$$T^{o} = 150\ ^{\circ}\text{F.}$$

$$n = 2.7$$

$$k^{I} = 3.24 \times 10^{-10}T + 1.92 \times 10^{-6}\ \frac{\text{B.t.u.}}{(\text{sec.})\ (\text{in.})\ (^{\circ}\text{F.})}$$

$$\rho^{II} = \frac{(P + 27.000)\ (0.0361)}{(6.44T + 0.822P + 25{,}150)}\ \frac{\text{lb.}_{m}}{\text{cu. in.}}$$

$$c_{p}^{III} = 1.1041 - 7.3340 \times 10^{-3}T + 2.5333 \times 10^{-5}T^{2} - 2.5980 \times 10^{-8}T^{3}$$

[a]From these collected papers: 1. R. B. McTaggert, presented at 3rd National Heat Transfer Conference, Storrs, Conn., Aug. (1959). 2. R. S. Spencer, and G. D. Gilmore, J. Appl. Phys. 20, 502 (1949). 3. R. H. Boundy and R. F. Boyer, "Styrene, Its Polymers, Copolymers and Derivatives," p. 479, Reinhold Pub. Co., New York, (1952).

channel being filled, and in all preceding channels, as a function of time (1). On the basis of earlier results, which indicated that rheological properties measured in the steady state hold at every point in the fluid, one might solve the equations of motion simultaneously with the energy equation, starting at the first non-isothermal channel (if there are more than one in series) and expect a good description of the process.

If inertia and radial velocity components are neglected, this would be related to the problem treated numerically by Gee and Lyon (5). They considered a tube filled with polymer at a constant temperature T_c. At time zero a constant pressure P'_r was applied to the inlet of the tube and the wall temperature was changed to T_D. At subsequent times, additional fluid entered the tube at temperature T_c.

In this discussion the conduit is initially empty and as time progresses the length of filled conduit increases and the pressure at the cavity inlet varies. Although radial velocity components, *i.e.*, material moving from the center of the melt toward the walls of the cavity, may not have a significant effect on momentum transfer, they may have a major effect on the flow. If, for example, there were no radial flow at the wave front, or front edge of the melt advancing in the cavity, the flow into a cavity would produce a wave front shaped like an "icicle," because of the no-slip condition at the wall, rather than the fairly flat wave front which is observed (3).

The type of radial flow which must exist at the wave front determines what particular part of the fluid at the wave front is deposited at the wall as the fluid moves along and this affects the subsequent heat transfer. This wave front complication makes the analysis of a filling cavity considerably more difficult than that of flow through a filled tube. Thus an attempt was made to obtain a first approximation of the effect of heat transfer on the mean velocity by first radically simplifying the problem.

The energy equation for flow between two wide flat plates with negligible axial conduction is (6),

$$\frac{\delta T}{\delta \theta} + \mu\,\frac{\delta T}{\delta x} + v\,\frac{\delta T}{\delta y} = \frac{k}{\rho c_p}\,\frac{\delta^2 T}{\delta y^2} + \frac{T\epsilon u}{\rho c_p}\,\frac{\delta P}{\delta x} + \frac{\phi}{\rho c_p} \qquad \text{Eq. 2}$$

The equation is simplified by dropping the expansion and heat generation terms (the last two terms on the right) and the effect of the velocity profile on the heat transfer is neglected by assuming that the heat transfer is the same as if the flow were "slab-like." The temperature profile at any cross-section is now fixed by the time the fluid at that cross-section has spent in the cavity. Thus, Eq. 2 reduces to Fourier's Equation,

$$\frac{\delta T}{d\theta'} = \frac{k}{\rho c_p}\,\frac{\delta^2 T}{\delta y^2} \qquad \text{Eq. 3}$$

with the boundary conditions

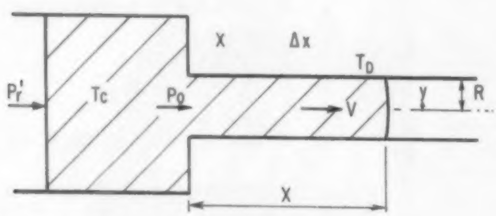

FIG. 1: Schematic diagram of non-isothermal cavity on channel flow system. See Table I on p. 117 for definition of terms.

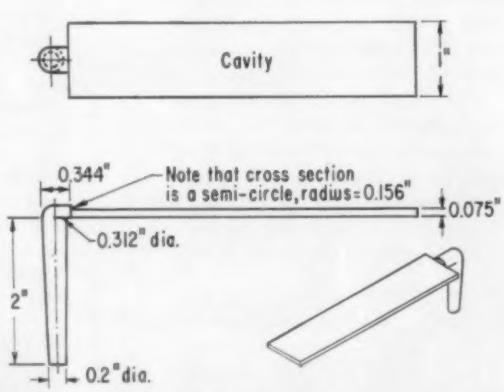

FIG. 2: Experimental mold cavity arrangement showing location and size of sprue and gate system.

$$T(y, O) = T_o \qquad \text{Eq. 4}$$

$$T(R, \theta') = T_D \qquad \text{Eq. 5}$$

$$\frac{\delta T\ (O, \theta')}{\delta y} = O \qquad \text{Eq. 6}$$

where θ' is the time an element would have spent in the cavity if the velocity profile were flat, i.e., the time corresponding to the fluid at any x is

$$\theta' = \int_0^x \frac{dx}{V} \qquad \text{Eq. 7}$$

The solution to Eq. 3 is

$$\frac{T - T_o}{T_D - T_o} = f\ (y, \theta') \qquad \text{Eq. 8}$$

and f (y, θ') is given in Carslaw and Jaeger (4).

The relationship between pressure gradient and mean velocity is obtained by combining the measured rheological relationship for unidirectional flow with a force balance between two wide flat plates (2),

$$\frac{du}{dy} = -A(T)y^n \left(-\frac{dP}{dx}\right)^n \qquad \text{Eq. 9}$$

and integrating twice across the cavity and then by parts results in

$$-\frac{dP}{dx} = \left[\frac{RV}{\int_0^R A(T)y^{n+1}\,dy}\right]^{\frac{1}{n}} \qquad \text{Eq. 10}$$

for a constant density

$$\left.\frac{\delta V}{\delta x}\right|_{\theta} = O \qquad \text{Eq. 11}$$

The above equations describe the flow inside the cavity and it remains necessary to specify the conditions at the cavity inlet; these conditions being set by the interaction between the cavity and the system preceding the cavity proper.

It is assumed that the system preceding the cavity is isothermal. This makes the total resistance to flow in all preceding channels independent of time and since P_o is zero at the instant the wave front enters the cavity, it follows from (2) Eq. 18 that the cavity inlet pressure is related to the mean velocity in the cavity by

$$\frac{P_o}{P'_r} = 1 - \left(\frac{V}{V_o}\right)^{\frac{1}{n}} \qquad \text{Eq. 12}$$

The assumption also makes the temperature entering the cavity, T_o, equal to the cylinder temperature; so if V_o and P'_r are known, the interaction between the cavity and the preceding parts of the system is contained in Eq. 12.

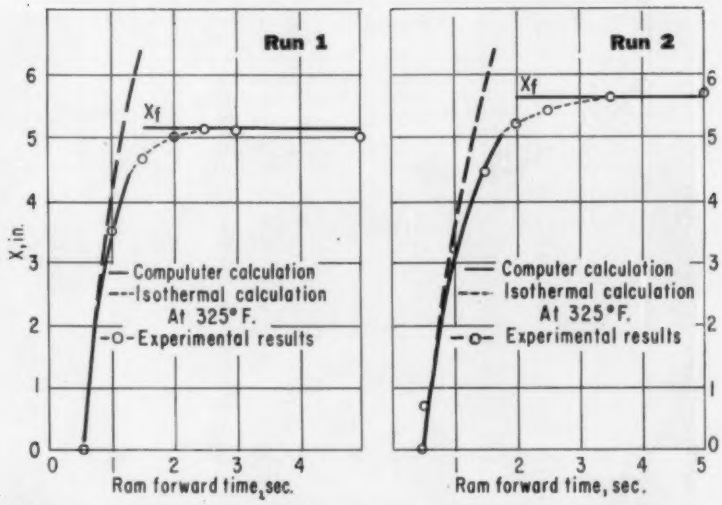

FIG. 3: Results from two experimental runs made with polystyrene using different mold temperatures and slightly different pressures. (See Table III, below). Note close agreement of experimental points with curves calculated from non-isothermal equations developed in this paper.

Table III: Conditions for experimental runs[a]

Run	T_o °F.	*Td* °F.	P_r p.s.i.	*R* in.
1	325	80	14,800	0.0375
2	325	180	13,550	0.0375

[a]Graphical results are plotted in Fig. 3.

Method of computation

Equation 10 was evaluated by first substituting the measured relationship for A(T) from Table II, p. 118.

$$-\frac{\delta P}{\delta x} = \left[\frac{RV}{A_0 \int_0^R F(y)\,dy}\right]^{\frac{1}{n}} \qquad \text{Eq. 13}$$

where

$$F(y) = y^{n+1}\,(e) - \frac{b}{T(y) - T^0} \qquad \text{Eq. 14}$$

and then using Simpson's rule

$$\int_0^R F(y)\,dy = \frac{R}{6}\,F(R) + 4F\left(\frac{R}{2}\right) + F(O) \qquad \text{Eq. 15}$$

Since $F(O) = O$

$$\int_0^R F(y)\,dy = \frac{R}{6}\,F(R) + 4F\left(\frac{R}{2}\right) \qquad \text{Eq. 16}$$

so

$$-\frac{dP}{dx} = \frac{V}{A^0\left(F(R) + 4F\left(\frac{R}{2}\right)\right)^{\frac{1}{n}}} \qquad \text{Eq. 17}$$

It is also true that:

$$P_o = \int_0^X -\frac{\delta P}{\delta x}\,dx \qquad \text{Eq. 18}$$

P_o was determined by summing the pressure gradient times the increment size over the length of the channel that contained fluid.

The calculation was as follows:

1) An increment size, Δx, was selected (Fig. 1) for the calculation along the channel.

2) A value of *V* was assumed.

3) $\Delta\theta'_1 = \frac{\Delta x_1}{V}$ and $\theta' = \theta'_1 + \Delta\theta'_1$ were calculated.

4) y = O was taken at the center

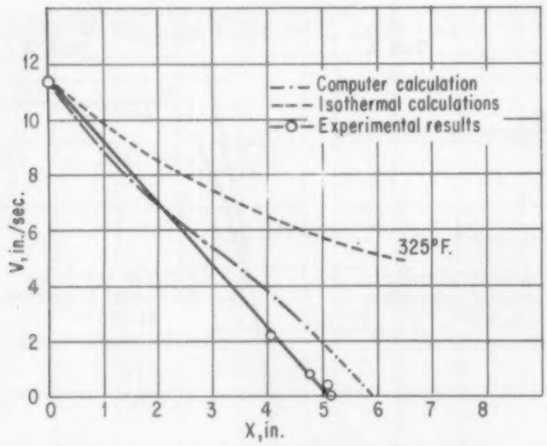

FIG. 4: Graph showing mean velocity, **V**, of polymer melt moving in cavity plotted against distance front edge of polymer has advanced into cavity at mold temperature of 80° F. All curves shown in Table III, p. 119, for Run 1. Note that calculated non-isothermal curves more closely describe actual experimental observation than does the calculated isothermal curve. Deviations are still present due to assumptions inherent in the non-isothermal curve.

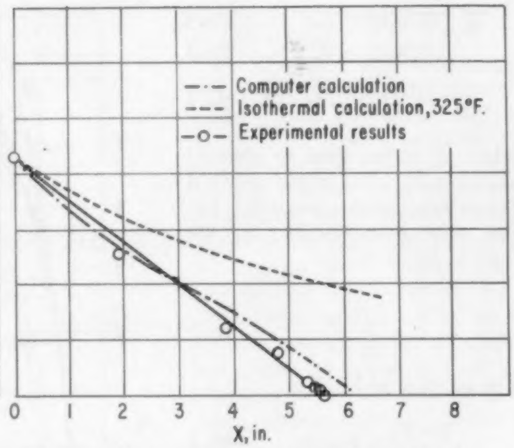

FIG. 5: Graph showing mean velocity, **V**, of polymer melt moving in cavity plotted against distance front edge of polymer has advanced into cavity, **X**, at mold temperature of 180° F. All curves were developed for conditions shown in Table III, p. 119, for Run 2. Note that calculated non-isothermal curves more closely describe actual experimental observation than does the calculated isothermal curve shown uppermost in the graph.

of the channel and the range O to R divided into 10 increments R/10, 2R/10, etc.

5) T(R) and T(R)/2 were calculated from Eq. 8, using the calculated value of θ'.

6) $\partial P/\partial x$ was calculated from Eqs. 14 and 17.

7) P_o was calculated from Eq. 12 and from Eq. 18. (P'_r was assumed constant.)

8) If the values of P_o so calculated did not agree a modified value of V was assumed and steps **3)** to **8)** were repeated.

9) When convergence was obtained, the calculation was continued into the next increment, Δx. With the new V and θ' all preceding increments must be recalculated since the velocity through the channel must be constant.

10) This stepwise procedure was continued until $V \cong O$, *i.e.*, the material has frozen. (Actually, at some small value of V the denominator in Eq. 17 goes to zero at some x and the approximation used in Eq. 16 would have to be modified if it were desired to continue calculations to any smaller value of V.

The above numerical procedure has been programmed, both for the IBM 702 and the IBM 704. The average running time per case on the 702 was about 20 hours. A single case can be run on the 704 in approximately 10 minutes. The program prints out the converged velocity, V, and a complete temperature distribution in the y direction for each increment from the entrance of the channel up to the leading edge of the fluid in the channel. It does this each time the fluid advances another increment Δx into the channel. The computation continues until the velocity V is zero or close to zero.

The method of correction for V was to use V_o as the first assumed value and then subtract a constant amount from the assumed V until P_o (Eq. 12) P_o (Eq. 18) changed sign. After this point new values of the assumed V were obtained by averaging the last value of V that gave a positive difference with the last value that gave a negative difference. This can be made to converge to any required degree of accuracy.

The 704 program was written using Fortran and, of course, made use of floating point arithmetic. The use of floating point arithmetic and the inherent greater computing speed of the 704 combined to reduce the running time on the 702 which used fixed point arithmetic on large number fields.

The material used was the commercial polystyrene, Compound B described earlier (2). The properties used are given in Table II. The relatively small density changes were approximately accounted for in the heat transfer calculations, but were neglected in the flow equations.

Experiment

The experimental technique was the same as described previously (3) (only the 3-oz. press was used here) except that the non-isothermal channels feeding the cavity were considerably shortened (Fig. 2, p. 118) in order to reduce the heat transfer in the channels preceding the cavity. In addition, the polymer pressure at the nozzle was directly measured with a pressure transducer and the maximum pressure reached during a run was taken to be P'_r since it was assumed that the ram pressure was constant during the filling of the cavity (3).

Results and discussion

The measured relationships among mean velocity time and distance were, as expected, the same as found earlier (1). Thus, as shown in Fig. 3, p. 119, the length of flow increased with time in an exponential fashion closely described by

$$\frac{X}{X_f} = 1 - (e) - \frac{\theta}{B} \qquad \text{Eq. 19}$$

where θ is **(To page 207)**

*Johnson reel (Denison-Johnson Corp.); Imperial 8 radio (Admiral Corp.); Aqua Hone sharpener (Sun Enterprises, Inc.)

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S.P.E. Technical Conference

Program scheduled to be presented at the 17th annual meeting

The 17th Annual Technical Conference of the Society of Plastics Engineers will be held Jan. 24-27, 1961, at the Hotel Shoreham, Washington, D. C. The tentative program follows:

Tuesday, Jan. 24

Session 1: Test methods. *Moderator: J. B. DeCoste.*

"Determination of heat distortion characteristics of rigid materials by means of a torsional apparatus." *N. L. Perry, Argus Chemical Corp.*

"Evaluation of high-impact polystyrene for refrigerator door liners." *D. A. Davis, J. V. Schmitz, R. S. Hagan, and R. O. Carhart, General Electric Co.*

"Microscopic examination of decorative laminates." *P. E. Willard, J. N. Jessup, and J. Kreinik, Food Machinery & Chemical Corp.*

"Pitfalls in predicting the performance characteristics of high-density polyethylene." *V. L. Folt and R. J. Ettinger, Goodrich-Gulf Chemicals Inc.*

Session 2: Extrusion. *Moderator: Paul N. Richardson.*

"Extrusion plastification." *L. F. Street, Welding Engineers Inc.*

"Application guide to extruder pressure measurements." *R. L. Eckman and G. A. Pettit, Barber-Colman Co.*

"Flow patterns in a non-Newtonian fluid in a single-screw extruder." *W. D. Mohr, J. B. Clapp, and F. C. Starr, E. I. du Pont de Nemours & Co. Inc.*

"Heating capacity limitations of extruder screws." *B. H. Maddock, Union Carbide Plastics Co.*

Session 3: Electrical insulations. *Moderator: Alexander E. Javitz.*

"A study of polymers applicable to insulation systems." *K. A. Torossian and S. L. Jones, General Electric Co.*

"Moisture-resistant coatings for Class B printed circuitry." *Arthur F. Ringwood, General Electric Co.*

"Improved reliability for printed circuits with protective coatings." *Edward W. McGuiness, Laboratory for Electronics Inc.*

"Mica as a reinforcing material for printed circuit and terminal board." *E. G. Dingman, The Macallen Co. Inc.*

Session 4: Reinforced plastics, Part I. *Moderator: George Lubin.*

"Simplified analysis of filament reinforced plastic pressure vessels." *R. J. Brown Jr., Aero-jet General Corp.*

"Service life estimates for FRP structures on basis of accelerated fatigue tests." *R. P. Molt, Stanray Corp.*

"Glass-reinforced plastic aviation gas turbine compressor housing." *C. H. Vondracek and R. N. Sampson, Westinghouse Electric.*

"Nature's and man's approach to filament reinforcement." *Curt A. Knoppel, Proman Inc.*

Session 5: Crosslinking of polymers. *Moderator: Paul E. Willard.*

"The promotion and retardation of cross-linking in thermally processed polyvinyl chloride systems." *Charles H. Fuchsman, Ferro Chemical.*

"New crosslinkers for furfuryl alcohol resins." *Erik R. Nielsen, Armour Research Foundation, Illinois Institute of Technology.*

"Chemically cross-linked polyethylene." *B. C. Carlson, R. T. Vanderbilt Co., Inc.*

Session 6: Extrusion panel. *Moderator: Frank Nissel.*

"Extrusion equipment," "Extrusion resins and compounds," and "Extrusion process techniques." Speakers to be announced.

Session 7: Reinforced plastics, Part II. *Moderator: George Epstein.*

"High temperature resin developments for filament winding." *J. Vernon Kindall and Samuel E. Susman, Narmco Industries Inc.*

"A study of maleate and fumarate polyester resins." *Robert E. Park, Ruth M. Johnston, Arthur D. Jesensky, and Robert D. Cather, Pittsburgh Plate Glass Co.*

"The effect of finishes on heat-resistant phenolic and modified epoxy laminate systems." *John Miglarese, Westinghouse Electric.*

Session 8: Thermoplastics. *Moderator: Hiram McCann.*

"Plasticizers made from synthetic (ALFOL) fatty alcohols." *B. W. Terry and W. L. Groves, Continental Oil Co.*

"Paste extrusion of filled compositions of Teflon 6 TFE-fluorocarbon resin for wire insulations." *R. W. Johnson, Du Pont.*

"Processing characteristics and applications of Estane thermoplastic polyurethanes." *C. A. Waugana, B. F. Goodrich Chemical Co., Development Center.*

"Extra high impact polystyrenes." *J. C. Misko and J. A. Edler, Union Carbide Plastics Co.*

"Properties of thin films of poly-(1,4-cyclohexylenedimethylene) terephthalate." *M. T. Watson, Tennessee Eastman Co.*

"Self-extinguishing polystyrenes." *J. C. Misko* and *C. F. Martino, Union Carbide Plastics Co.*

"Polyvinylidene fluoride-RC 2525. Part 1. Properties." *W. S. Barnhart, R. A. Ferren, and H. Iserson, Pennsalt Chemicals Corp.* "Part 2. Fabrication and application." *N. Capron, A. A. Dukert, M. E. Milville, and L. E. Robb, Pennsalt.*

Session 9: Thermosets. *Moderator: Malcolm W. Riley.*

"Fabrication of high temperature molds and dies using new epoxy resin systems." *Tom Schaub, Furane Plastics Inc.*

"New techniques in applying epoxy troweling compounds." *T. S. Loeser, Union Carbide Plastics Co.*

"Dimensional stability improve-

ment of melamine impact molding compounds." *W. A. Laurie, Melamine Plastics Corp.*

"New heat resistant phenolic molding materials." *W. G. Colclough, J. Harding, and C. Y. Meyers, Union Carbide Plastics.*

"High-strength laminating varnishes for paper-base phenolic tubing." *T. G. Crawford, Westinghouse Electric Co.*

Wednesday, Jan. 25

Session 10: Polymer properties, Part I. *Moderator: Herman S. Kaufman.*

"The different states of polymers based on their thermochemical properties." *M. Chatain and P. Dubois, Centre d'Etude des Matieres Plastiques, France.*

"Measurement of orientation in polystyrene film and sheet." *C. T. Hathaway, Monsanto Chemical Co.*

"An analysis of density data from annealed polypropylene film." *Edward D. Henze, Kordite Co., and Frank Sliemers, Battelle Memorial Institute.*

"Thermodynamic diagrams for polyethylene resins." *J. M. Lupton, E. I. du Pont de Nemours & Co. Inc.*

Session 11: Injection molding, Part I. *Moderator: Jerome L. Formo.*

"Effects of basic polymer properties on injection molding behavior." *R. B. Staub, Union Carbide Plastics Co.*

"Injection molding machines—1961." *W. G. Kriner, The Hydraulic Press Mfg. Co.*

"Comparison between plunger and screw injection units." *Richard Maier and Andre Thierstein, Buhler Bros., Switz.*

"Molding high-density polyethylene in large boxes, trays, and lids." *J. V. Smith, C. G. Williams, and L. R. Alexander, Phillips Chemicals Co.*

Session 12: Statistics panel. *Moderator: L. M. Debing.*

Panel members: *Dr. W. J. Youden, National Bureau of Standards* ("Design of experiments"); *Dr. A. J. Duncan, Johns Hopkins University* ("The control of manufactured quality-control charts for attributes"); *Dr. W. R. Pabst Jr., Bureau of Naval Weapons, Navy Dept.* ("Sampling plans"); and *Francis J. Cullen, National Plastics Products Co.* ("Use of frequency distributions in setting specifications.")

Session 13: General session, Part I. *Moderator: Ernie Moslo.*

"Toxicology of aliphatic amine curing agents in epoxy tooling systems." *H. L. Thomas and J. W. Guyer, Ren Plastics Inc.*

"Hydraulic fluids; fact and fancy." *George R. Arbocus, E. F. Houghton & Co.*

"Controlling quality in a plastics processing plant." *Walter C. Siff, The General Tire & Rubber Co.*

"General Topic: Plastics in electrical applications." *Louis M. Kline, Underwriters' Laboratories.*

Session 14: Heat stable polymers. *Moderator: B. G. Achhammer.*

"Research and development of high temperature stable polymers." *Harold H. Levine, Narmco Industries Inc.*

"Inorganic-organic high polymers, phenoxyaldehyde resins of titanium (IV), zirconium (IV), and hafnium (IV)." *R. J. Landry and E. H. Bartel, U. S. Naval Ordnance Test Station.*

"Heat resistance and molecular structure." *Elwood Strebel, Cincinnati Test Laboratory.*

Session 15: Injection molding, Part II. *Moderator: Roger Staub.*

"Comparison of spiral-cavity mold flow with laboratory scale flow tests on thermoplastics." *J. J. Gouza and G. G. Freygang, Rohm & Haas Co.*

"Hydraulics on plastic injection molding machines." *R. H. Mezger, Vickers Inc.*

"The rotating spreader—a device for superior injection molding." *Neil Keiser, Du Pont.*

Session 16: General session, Part II. *Moderator: R. K. Gossett.*

"Equipment and tooling for production with epoxy molding compounds." *John L. Hull, Hull Corp.*

"Foamed plastic particles—versatile new materials." *Betty Lou Raskin, Johns Hopkins University, Radiation Lab.*

"The molded-in hinge in polypropylene components." *Russell Hanna, Hercules Powder Co.*

Thursday, Jan. 26

Session 17: Polymer properties, Part II. *Mod.: James F. Carley.*

"The strength of glassy polymers." *J. P. Berry, General Electric Co.*

"Time dependent rupture of high impact thermoplastics." *T. V. Schmitz and R. S. Hagan, General Electric Co.*

"The environmental stress rupture of polyethylene used in blown bottle applications." *L. L. Lander, Union Carbide Plastics Co.*

"Hardness of polymeric materials." *Eric Baer and R. E. Maier, Du Pont.*

Session 18: Film and sheeting technology. *Moderator: J. W. Lindau.*

"Processing variables and their effects on properties of coatings made with polyethylene, polypropylene, and nylon 6." *John F. Morris, Spencer Chemical Co.*

"The effect of extrusion variables on the fundamental properties of tubular polythene film." *N. D. Huck and P. L. Clegg, Imperial Chemical Industries Ltd., England.*

"A comparison of blown and chill cast polyethylene film." *G. Denis Murphy, Spencer Chemical.*

"High speed-small unit polyethylene overwrapping." *R. H. Cording, Tennessee Eastman Co.*

Session 19: Finishing, Part I. *Moderator: Lee J. Zukor.*

"Design for plastic finishing." *F. Borries, G. Felsenthal & Sons.*

"Hot stamping of high luster metallic colors." *Martin A. Olsen, OlsenMark Corp.*

"Effect of coating properties upon sequence and economy of plastic decorating." *T. E. Hayden, Bee Chemical Co.*

"Design of modern vacuum metallizing equipment." *Howard Farrow, NRC Equipment Corp.*

Session 20: Vinyl plastisols. *Moderator: Saul Gobstein.*

"The mechanics and testing of plastisol gelation and fusion." *J. A. Greenhoe, Monsanto Chemical Co., Plastics Div.*

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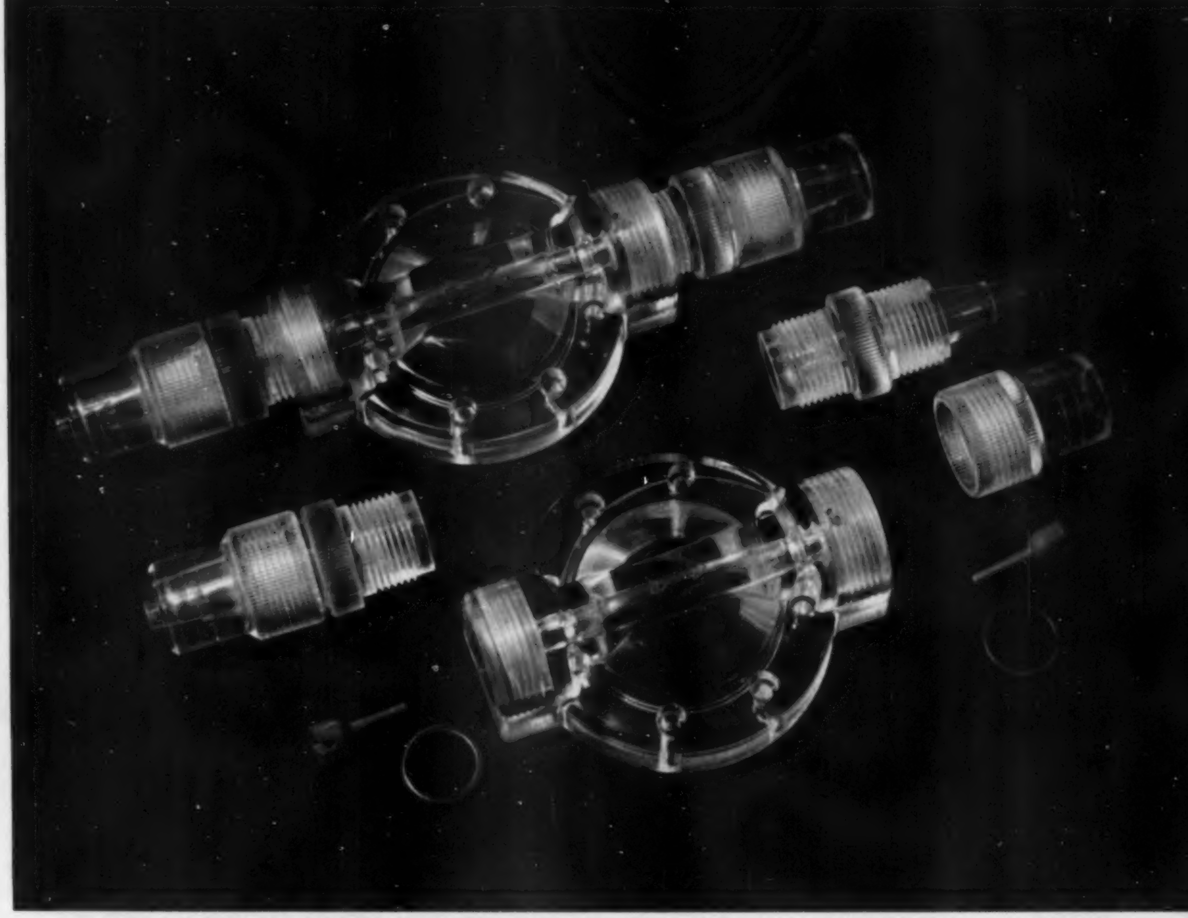

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strument, a new formulating technique." *W. H. Bauer, Union Carbide Chemicals Co.*

"Plastisol distribution in rotational casting." *L. A. McKenna, Union Carbide Plastics Co.*

"Vinyl plastisols for low temperature fusion." *J. C. Robinson, The Goodyear Tire & Rubber Co.*

Session 21: Stability of polymers. *Moderator: Herman Mark.*

"Electro-thermal analysis of thermosetting polymers." *R. W. Warfield, U. S. Naval Ord. Lab.*

"The effect of physical treatment on the stability of polyamides." *M. M. Epstein and C. W. Hamilton, Battelle Institute.*

"Effect of gamma radiation on chemical structure of plastics." *V. J. Krasnansky, M. S. Parker, and B. G. Achhammer, NBS.*

Session 22: Blow molding. *Moderator: Jules Pinsky.*

"Blow molding developments." *W. O. Bracken, Hercules Powder.*

"Trouble shooting in blow molding." *H. S. Malby, A. N. Ciarlone, C. M. Greene, Celanese Co.*

"Future uses of the blow molding process." *R. L. Wechsler, Union Carbide Plastics Co.*

Session 23: Finishing, Part II. *Moderator: T. E. Hayden.*

"Automatic spray painting." *C. V. Scantlebury and H. P. Miskill, Finish Engr. Co. Inc.*

Panel: *John Scharnberg, Martin Olsen, Fred Borries, C. V. Scantlebury, Howard Farrow, Lee J. Zukor, Angelo Larareo, and Ronald Cleveringa.*

Topics: "Decorating polyolefins," "Automation for finishing," and "Overcoming vacuum metallizing production problems."

Friday, Jan. 27

Session 24: Weatherability. *Moderator: John B. Howard.*

"The outdoor durability of plasticized polyvinyl chloride." *J. R. Darby and P. R. Graham, Monsanto Chemical Co.*

"Weathering of epoxy resin systems." *Frank E. Pschorr and A. N. Cianciarulo, CIBA Products Corp.*

"The predominant reaction of some fluorinated polymers to ionizing radiation." *Robert Timmerman, Radiation Dynamics Inc., and William Greyson, HiTemp Wires Inc.*

"Status of investigations for improving the weatherability of linear polyethylene and copolymers." *C. Gottfried and M. J. Dutzer, Celanese Plastics Co.*

Session 25: Rheology of polymers. *Moderator: Bryce Maxwell.*

"Polyethylene flow data from melt viscometer and commercial extruder measurements." *H. P. Schreiber, Central Research Canadian Industries Ltd., Canada.*

"Measurement of the flow of molten polymers through capillaries." *A. P. Metzger, Battelle.*

"Flow properties of some commercial thermoplastics—end corrections in capillary flow and their implications in die design and polymer processing." *L. B. Ryder, Celanese Corp. of America.*

"Effect of static pressure on polymer melt viscosities." *Dr. J. F. Carley, U. of Ariz.*

Session 26: Heat resistant plastics. *Mod.: Lawrence Shenker.*

"Utilization of plastics in seal design for extreme environments." *Frank Tipton and George Trepus, Boeing Airplane.*

"Rapid heating method for testing plastics and adhesively-bonded systems." *M. S. Allison, A. C. Johnson, and R. B. Stabler, Lockheed Aircraft Corp.*

"Developments in heat resistant-structural non-woven fiber reinforced plastics." *D. V. Rosato, Telecommunications.*

"The development of a reliable insulation for solid propellant rocket motors." *S. P. Prosen and M. A. Kinna, U.S.N. Ord. Lab.*

Session 27: General session, Part III. *Mod.: Peter Simmons.*

"Comparison of plastisol extrusion coating with conventional coating methods." *C. H. Brower, Union Carbide Plastics Co., and R. A. Nunn, Waldron-Hartig Div.*

"Adhesive bonding: a new concept in structural adhesives." *Frank J. Riel, Narmco Industries.*

"Effect of molding conditions on shrinkage of modified polystyrene." *R. G. Hochschild, Koppers.*

"Presentation of data on cushioning materials." *W. G. Soper, Clinton, Md., and R. C. Dove, University of New Mexico.*—**End**

Reinforced plastics conference

Program of 16th annual session, to be held Feb. 7-9, 1961, at the Edgewater Beach Hotel, Chicago, Ill.

Registration for the 16th Annual Conference of the Reinforced Plastics Div. of The Society of the Plastics Industry Inc. will begin at 1:00 p.m. on Monday, Feb. 6, 1961, in the main lobby foyer of the Edgewater Beach Hotel. The tentative program follows:

Tuesday, February 7

9:30 A.M. to 12:00 Noon—Three concurrent sessions.

Session I—Materials, Part 1

Presiding: William J. Eakins, DeBell & Richardson Inc.
Vice Chairman: L. Stievater Jr., McKesson & Robbins Inc.

"Oxiron Resins—A Series of New Epoxy Resins," F. P. Greenspan and C. W. Johnston, Food Machinery & Chemical Corp.

"Non-Metallic Fiber Reinforced Ceramic Laminates," H. T. Plant, R. Girard, and H. Wisely, G.E.

"A New Self-Extinguishing Epoxy Resin," Sam N. Ephraim and S. W. Street, Reichhold.

"Bias Fiberglass Cloth for Reinforced Plastic Laminates," J. A. Henry and D. A. DePeter, Exeter Manufacturing Co.

"Elevated Temperature Resistance of Phenolic and Modified Phenolic Resin Laminates," R. D. Knopes, Reichhold Chemicals Inc.

Session II—Plastics for Tooling

Presiding: Fred Lyijynen, Stamping Div., Chrysler Corp.
Vice Chairman: William Ibsen, CIBA Products Corp.

"Plastic Master Models," Steve Kish, Kish Industries Inc.

"Setting Characteristics of Tooling Resins and Effects on Fabrication," Lewis F. Bogart, Tool Chemical Co.

"Tooling with Plastic Faced Plaster," Melvin K. Young, United States Gypsum Co.

"The Effects of Fiber Metal Fillers on the Physical Properties of Epoxy Resin Systems," F. Holtby, U. of Minn.; R. Forester, G. H. Tennant Co., and D. M. Akins, Remington-Rand Univac.

"New Techniques and Materials for Construction of High Temperature Tooling," Tom Schaub, Furane Plastics Inc.

Session III—Design

Presiding: George Lubin, Grumman Aircraft Engineering Corp.
Vice Chairman: Frank Wille, AVCO Corp.

"Development of Nondestructive Test for Plastics," S. Goldfein, Chief, Plastics Section, U. S. Army, Fort Belvoir, Va.

"Designing with Filament Winding," J. Medney, C. Kurz, and J. L. McLarty, Lamtex Ind.

"Development, Design, and Production of Plastic-Impregnated Paper Honeycomb to Fit Curved Surfaces," R. W. Weaver, Sandia Corp.

"Matched-Die Molded Integrally-Stiffened RP Structures," B. D. Raffel and W. J. Hampshire, Goodyear Aircraft Corp.

12:30 to 2:00 P.M.—Luncheon.
Presiding: Donald G. Estey, American Cyanamid Co.
Principal Speaker: Clare Bacon, Owens-Corning Fiberglas Corp.
Subject: "Reinforced plastics' unlimited—an expression of confidence in the future."

2:00 to 5:00 P.M.—Three concurrent sessions.

Session I—Materials, Part 2

Presiding: T. J. Jordan, General Electric Co.
Vice Chairman: John C. Schlegel, American Cyanamid Co.

"Novel Allylic Laminates," Harry Raech Jr. and J. L. Thomas, Food Machinery & Chemical Corp.

"The Formulation and Processing of Isophthalic Unsaturated Polyesters," F. A. Cassis, J. F. Mayer, and P. C. Dougherty, Amoco Chemicals Corp.

"Peroxide Curing of Unsaturated Polyesters. I. Effect of Some Accelerators and Inhibitors," David C. Noller, Suzanne D. Stengel, and Orville L. Mageli, Lucidol Div., Wallace & Tiernan.

"A Continuation of the Comparative Study of the Corrosion Resistance of a Bisphenol A Polyester and Various Other Polyester and Epoxy Resins," A. F. Torres and S. S. Feuer, Atlas Powder Co.

Authors' Panel Discussion.

Session II—Plastics in Building

Presiding: George A. Stein, Archer-Daniels-Midland Co.
Vice Chairman: G. William Burton, Westinghouse Electric Corp.

"The Use of Reinforced Plastics in Mexican Rural School Construction," Ernesto Arriola, Vitro Fibras, Mexico.

"Reinforced Plastics Plus Rigid Vinyl—A New Method of Plastics Construction," G. Ader, Art-rite Resins Ltd., London, Eng.

"Reinforced Plastics as Components in Residential Housing," Lee Frankl, Designer.

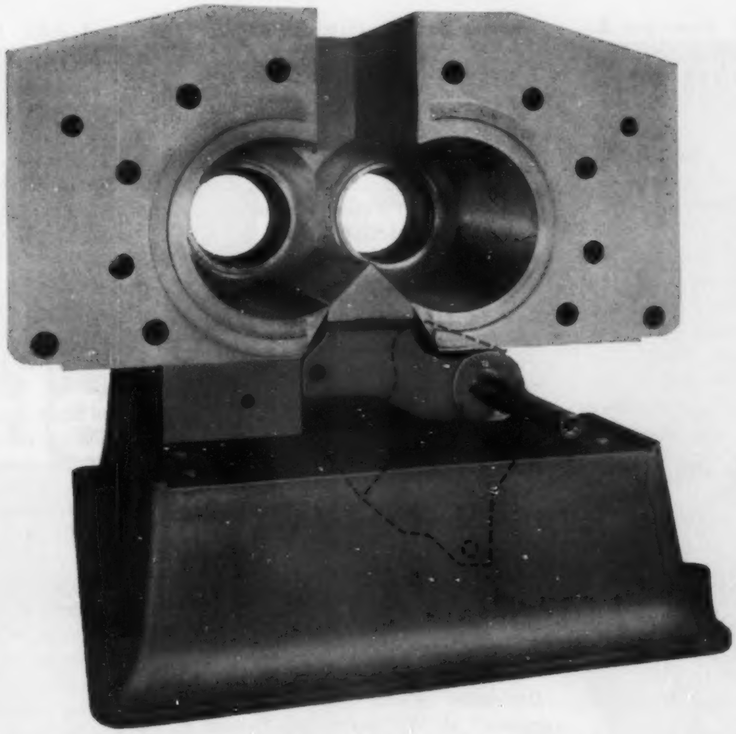
"Building Codes, and Their Effects Upon the Uses of Plastics," Frank X. Ambrose, Alsynite Div., Reichhold Chemicals and H. Perrine, Code Consultant for S.P.I.

"Contour-Matched Metal Molded Glass Reinforced Plastics for Outdoor Use," R. C. Harper and F. H. Bratton, Cincinnati Molding Machine Co.

Session III—Applications, Part I

Presiding: Elliott Dorman, CIBA Products Corp.
Vice Chairman: Arthur J. Wiltshire, Structural Fibers Inc.

"Weather Shields for Use on 3"/50 Twin Mounted Rapid Fire



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Left: Size 9D Banbury with spray-cooled sides for most efficient cooling can also be used with up to 15 pounds of steam for moderate heating.
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FB-1206

Guns on R. C. N. Destroyer Escorts," Harry Walker, Dominion Rubber Company Ltd.

"Chains of Glassfiber-Reinforced Plastics," Dr. Ing. Paul Koch, Director of Kettenwerke Schlieper GmbH., Germany.

"Design and Construction of a 24-ft. Airborne Rotodome," George Lubin, R. Imgram, and W. Atchison, Grumman Aircraft Engineering Corp.; James E. FitzGerald, Brunswick Corp.

"Award Winners—One Year Later!," W. Burdette Wilkins, Reinforced Plastics Container Corp.

Authors' Panel Discussion.

8:00 to 10:30 P.M.—Three Concurrent sessions.

Informal Session of S.P.I. Pre-Form and Mat Die-Molding Committee, revolving around summary papers of basic consideration to be bound in preprint.

Informal Session by S.P.I. Prepreg RP Committee.

Seminar—The Glass-Resin Interface.

Presiding: H. A. Perry Jr., U.S.N. Lab., Silver Spring, Md.

Vice Chairman: P W. Erickson, U.S.N. Lab., Silver Spring, Md.

Introductory Remarks: Henry A. Perry Jr.

"Physical Techniques Used in Studying Interfacial Phenomena," Robert L. Patrick, Alpha R & D.

Remarks on Techniques Paper: Robert R. Stromberg, National Bureau of Standards.

"Chemistry of Chromium Complexes as Coupling Agents in Fiberglass-Resin Laminates," Paul C. Yates and John W. Trebilcock, Experimental Station, E. I. du Pont de Nemours & Co., Inc.

Remarks on Chemistry of Chrome Complexes Paper: Alfred Marzocchi, Owens-Corning Fiberglas Corp.

"Interaction of Organic Monomers and Water with Fiberglass Surfaces," Kurt Gutfruend and H. S. Weber, Armour Research Foundation, Ill. Inst. of Tech.

Remarks on Interaction at Fiberglass Surfaces Paper: Harold A. Clark, Dow Corning Corp.

"A New Interpretation of the Glass-Coupling Agent Surface Through Use of Electron Microscopy," H. B. Bradley and Sam Sterman, Union Carbide Corp.

Remarks on Application for Electron Microscopy Paper: Charles B. Sias, Pittsburgh Plate Glass Co.

"A Study of the Finish Mechanism: Glass to Finish, Finish Thickness, and Finish to Resin," W. J. Eakins, DeBell & Richardson.

Remarks on Finish Mechanism Paper: F. J. McGarry, MIT.

Wednesday, February 8

9:00 to 12:00 Noon—Three concurrent sessions.

Session I—Premix

Presiding: Robert J. Brinkema, Firmaline Products, Crompton & Knowles.

Vice Chairman: Lawrence Wittman, Lawrence Wittman Co.

"Comparison of Reinforcements and Study of Certain Processing Variables in Premix Moldings," H. Doob Jr. and T. E. Phillips, Owens-Corning Fiberglas.

"Quality Control of the Mixing Operation at The Glastic Corporation," R. W. Meyer and Ralph Orkin, The Glastic Corp.

"Polyester Premix: Performance in Relation to Resin and Formulating Procedure," Carl A. Marszewski and S. E. Leeper, Allied Chemical Corp.

"Premixes Based on Hydrocarbon Resins," B. M. Vanderbilt and R. E. Clayton, Esso Res. & Eng.

"Flow of Premix Compounds," Peter L. Shanta and Robert J. Pushaw, Raybestos-Manhattan Inc. (to be followed by discussion on this subject by Chairman of S.P.I. Premix Committee, Richard F. Doyne, Atlas Powder Co.).

Authors' Panel Discussion.

Session II—Flight Vehicles

Presiding: Samuel S. Oleesky, Consultant.

Vice Chairman: T. B. Blevins Jr., Office of the Chief of Ordnance, Department of the Army.

"Reinforced Plastic Helicopter Blades," Frank L. Stulen, Parsons Corp.

"Stability of the Protective Ultraviolet Absorbers in Terrestrial and Space Environments," R. C. Hirt, R. G. Schmitt, and N. Z. Searle, American Cyanamid Co.

"Structural and Insulative Characteristics of Reinforced Plastics Materials During Ablation, Franklin A. Vassalo, Norman E. Wahl, Gerald A. Sterbutzel, and John L. Beal, Cornell Aeronautical Laboratory Inc.

"Effect of Composition and Fabrication Processes on Insulation, Ablation, and Erosion Characteristics of Plastics Used in Rocket and Missile Applications," R. C. Cooke, Thomas F. Anderson, and J. David Quinn, Haveg Industries Inc.

"Calorobic Plastics for Use in Rocket Motors," R. J. Landry and E. H. Bartel, USN Ord. Test Station, China Lake, Calif.

Professor C. S. Grove Jr., Director of Engr. Research, Syracuse U. Research Inst., to participate in panel discussion.

Session III—Applications, Part 2

Presiding: A. W. Levenhagen, Molded Fiber Glass Tray Co.

Vice Chairman: Costa J. Gongolas, Pittsburgh Plate Glass Co.

"The Status of the Reinforced Plastics Industry in Canada," K. Hutchinson, Fiberglas Canada Ltd.

"Reinforced Plastics in Automotive Styling," J. C. Henry, Engineering Div., Chrysler Corp.

"Designing and Testing a Fiberglass Stock for the M14 Springfield Rifle," Joseph Szanto and Nicholas Angelica, Springfield Armory, Springfield, Mass.

"Design and Mechanical-Electrical Characteristics of the 500-ft. Diameter Radome," G. C. Fretz Jr., C. J. Schmidt, J. T. Dorsey, and R. Davis, Goodyear Aircraft Corp.

"The Growth and Future of Reinforced Polyester Plastics—a Market Research Report," James E. Sayre, Plastics Div., Allied Chemical Corp.

12:30 to 8:00 P.M.—Luncheon.

Presiding: Hiram McCann, Editor-in-Chief, MODERN PLASTICS magazine.

Principal Speaker: William T. Scott, Atlas Powder Co.

Topic: *"Why Don't You Speak For Yourself, John!"*

7:00 P.M.—Annual Banquet.

Toastmaster: Samuel A. Moore, Interchemical Corp. and General Chairman of S.P.I. Reinforced Plastics Division.

Executive Committee Awards.

Awards For Outstanding Papers. **(To page 132)**

Thursday, February 9

9:00 to 12:00 Noon—Three concurrent sessions.

Session I—Research, Part 1

Presiding: Frederick J. McGarry, Massachusetts Institute of Technology.

Vice Chairman: Harry R. Nara, Case Institute of Technology.

"Glass-fiber Reinforced Plastics as Structural Material for the Aircraft Industry," Prof. Ulrich Hutter, Institute of Technology, Stuttgart, Germany.

"Bending Analysis of Directionally Reinforced Plastic Pipe," Verne C. Cutler, University of Wisconsin, College of Engr.

"Some Problems Investigated in the Study of Mechanical Aspects of Reinforcement," J. S. Islinger and F. K. Halwax, Mechanics Research Div., Armour Research Foundation.

"Effects of High Rates Compared with Static Rates of Loading on the Mechanical Properties of Glass Reinforced Plastics," Elise McAbee and Mitchel Chmura, Research Laboratory, Picatinny Arsenal, Dover, N. J.

"Flexural Behavior of Fiberglass Laminates," Frederick J. McGarry and Edward M. Krokosky, MIT.

Session II—Transportation, Part 1

Presiding: John F. Reeves, Consulting Engineer.

Vice Chairman: T. J. Welsh, Celanese Polymer Corp.

"Break-Through in Body Structures Utilizing Glass Fibers, Polymers and Plastics," Irwin J. Gusman, J. P. Stephens & Co., Inc.

"Truck Parts by Spray Molding," Urban S. Arbour, Techni-Glas Inc.

"Technology Advances Open New Doors for Reinforced Plastics in the Transportation of Cold Products," Kenneth C. Sanders, The Heil Co.

Session III—Boats

Presiding: Robert P. White, Naugatuck Chemical, Div. of United States Rubber Co.

Vice Chairman: George L. Smead, Midwestern Industries Corp.

"Comparison of Boat Construction—Aluminum vs. Fiberglass," H. E. Sholty, Lone Star Boat Co.

"Epoxies for Boating—A New Approach," C. H. Strong and John J. Madden, Union Carbide Plastics Co., Div. of Union Carbide Corp.

"Industrial Design in the Boating Market Place," Brooks Stevens, Brooks Stevens Assocs.

"Trends in the Boating Industry," Charles A. Jones, Editor, *"The Boating Industry."*

12:30 to 2:00 P.M.—Luncheon.

Presiding: Clare E. Bacon, Owens-Corning Fiberglas Corp.

Principal Speaker: Joseph E. Adams, The White Motor Co.

Subject: "The use of molded fiber glass in the truck transport industry."

2:00 to 5:00 P.M.—Three concurrent sessions.

Session I—Transportation, Part 2

Presiding: T. J. Welsh, Celanese Polymer Corp.

(To page 193)

Silane coupling agents in glass-reinforced plastics

By B. M. Vanderbilt† and J. P. Simko Jr.‡

Substitution of ethyl silane for vinyl silane in a glass-reinforced laminate made with a polybutadiene-type resin results in poor physical properties. These and other data indicate that the vinyl silane coupling agent can combine chemically with the resin during the curing process. Copolymerization studies with styrene and vinyl triethoxysilane indicate that some coupling of the vinyl silane with a polyester-styrene resin should occur at a cure temperature of 225° F. Use of higher temperatures results in more complete copolymerization of the vinyl silane. Styryl silanes are much more active in copolymerizations than the vinyl, but are of questionable utility as glass finishes. Divinyl silane appears to be superior to the monovinyl silane as a glass finish when used with a hydrocarbon or polyester resin. Drying heat-cleaned glass cloth at 840° F. prior to use in laminates results in improved clarity, strength, and water resistance as compared to drying at 212° F.

This article is essentially that of Section-10D presented at the 15th annual meeting of the Reinforced Plastics Div., The Society of the Plastics Industry Inc., held Feb. 2-4, 1960. Certain minor changes and additions, however, have been made, based on more recent data.

Reinforced plastics are heterogeneous mixtures. Even the simplest system involves two heterogeneous components—the resin and the reinforcing fibers. Alone, each is largely worthless as a useful structure. The importance of the resin bond to the reinforcement is obvious.

This article is limited to the consideration of glass as the reinforcing medium. Polybutadiene-type liquid resins and polyesters are considered as the laminating resins. As to coupling agents between glass and resin, only the silane types are discussed.

As is well known, coupling or finishing agents have been developed that have two types of active groups, one type to "react with the glass" and one type to "react with the resin." These are usually applied to glass fibers during the manufacturing process. As an example, glass fibers may be treated with vinyl trichlorosilane as a gas, in an inert solvent such as xylene, or as its hydrolytic product in water. Thus, three of the valencies of the silicon are used up in attaching to the glass surface or in intercondensation of the silane to form the siloxane type structure. The vinyl group is supposed to remain intact and react with the laminating resin, e.g., a polyester-styrene blend.

Several investigators by means of physical measurements have indicated that the vinyl group of the silane finish does not react with a polyester during the curing step, and that the bonding of resins to glass may be purely by physical adhesion.

In our laboratories we have had an opportunity to work with an all-hydrocarbon resin system in the preparation of glass cloth laminates. Such a resin does not chemisorb on the glass surface as well as do the more polar polyesters and epoxies. Thus, the glass finish plays a greater role in the wetting and adhesion of the glass to this hydrocarbon resin than with resins previously used. This makes possible a more sensitive system than has previously been available for studying the glass-resin bond in reinforced plastics.

In a recent publication one of us has reported on the effectiveness of vinyl silane coupling agents when using an all-hydrocarbon resin system consisting of an 80/20 copolymer of butadiene and styrene blended as a 60/40 or 50/50 blend with vinyltoluene. The present paper is an extension of the work reported in that publication (1)[1], and deals mainly with attempts to make the resin-glass bond stronger and more water resistant. Some of the information relates to polyesters.

Copolymerization with vinyl triethoxysilane

There are no analytical methods available to determine whether a film of vinyl siloxane on

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[1]Numbers in parentheses denote references at the end of the article, p. 217.

glass fibers is chemically coupled in the fabrication of a reinforced plastic. Thus, one must resort to indirect methods. Physical measurements have been one of the indirect methods employed(2). Another is to study vinyl-silicon monomers that should polymerize similarly. The esters of vinyl silicic acid are available and should have polymerization characteristics similar to, although not identical to, a hydrolyzed vinyl silane which has been laid down on a glass surface. It is well known that in a vinyl compound, constituents in the molecular chain greater than two positions from the vinyl group have little or no effect on the activity of the vinyl group. Thus, since all such compounds have the

$$CH_2 = CH - Si \begin{matrix} \diagup O- \\ -O- \\ \diagdown O- \end{matrix}$$

group in common, one would expect similar polymerization characteristics.

Considerable work has been done on the homopolymerization and copolymerization characteristics of vinyl triethoxysilane, as well as some work on the vinyl siloxanes prepared by hydrolyzing vinyl trichlorosilane(3). As pointed out in our previous publication(1), the literature indicates that vinyl silanes and siloxanes are very slow polymerizers and form either liquid or gummy polymers or copolymers. However, no work to our knowledge has been reported on copolymerizing a vinyl silane with the constituents employed in a polyester resin, under conditions typical of those used in curing such a resin.

Vinyl triethoxysilane (Union Carbide) was used as the silane ester because of its availability, resistance to hydrolysis, and its relatively low molecular weight. In a typical polyester system, the vinyl silane coupling agent can theoretically copolymerize either with the styrene or the polyester. In our polymerization studies we employed diethyl fumarate to simulate the polyester. In the case of the polybutadiene type resin, it is no doubt the styrene crosslinker which is the more likely constituent to react with the silane.

In our studies the vinyl triethoxysilane (VTES) was used as received; the styrene was the plastic grade, 99.5% purity, rendered inhibitor free by means of silica gel; and the diethyl fumarate was inhibitor free, reagent grade. The vinyl silane and second monomer were employed in equimolar proportions. To simulate conditions in reinforced plastics no diluent was used. A total of 10 g. of monomers in a 2-oz. bottle along with appropriate catalyst, under nitrogen, was heated under static conditions in a constant-temperature oil bath.

Table I, left, cites the results obtained when using the fumarate ester and VTES at relatively low temperature polymerization conditions for a polyester (225° F. with benzoyl peroxide), and at relatively high temperature polymerization conditions (275° F. with Dicup). As may be seen from the data, no copolymerization occurred with benzoyl peroxide and only liquid polymers were formed at the higher tem-

Table I: Bulk polymerization[a] of diethyl fumarate and vinyl triethoxysilane under polyester cure conditions

Monomers	*Catalyst*	*Temp.*	*Reaction time*	*Polymer*[b]
		°*F.*	*min.*	
Diethyl fumarate	1% benzoyl peroxide	225	240	No solid polymer; slight viscosity increase
Diethyl fumarate/ vinyl triethoxysilane 1:1 molar	1% benzoyl peroxide	225	230	No solid polymer; no viscosity increase
Vinyl triethoxysilane	1% benzoyl peroxide	225	200	No viscosity increase
Diethyl fumarate	2% dicumene peroxide (Dicup)	275	1100	No solid polymer; slight viscosity increase
Diethyl fumarate/ vinyl triethoxysilane 1:1 molar	2% dicumene peroxide (Dicup)	275	205	No solid polymer; solution viscous
Vinyl triethoxysilane	2% dicumene peroxide (Dicup)	275	205	Clear viscous oil[c]

[a]Bulk polymerization run without diluent; 10 g. combined monomers in 2-oz. screw cap bottles flushed with nitrogen before run. [b]Viscosity increase by visual observation. No further change on longer heating. [c]No solid formed on pouring into 99% isopropyl alcohol.

Table II: Bulk polymerization of styrene and vinyl triethoxysilane

Catalyst	*Temp.*	*Time*	*Yield*[a]	*Silicon*[b] *in product*
	°*F.*	*min.*	%	%
1% Benzoyl peroxide	225	60	20	2.3
2% Dicup	275	60	28	3.0
2% Dicup / 2% t-BP[c]	295	60	35	3.6

[a]Solid polymer recovered by pouring into 99% isopropyl alcohol. Purified by redissolving in toluene and again precipitating with the alcohol. [b]If monomers combined in same proportion as feed, silicon content would be 9.5 percent. [c]Di-*t*-butyl peroxide.

Table III: Bulk polymerization[a] of styrene and vinyl triethoxysilane under Buton cure conditions

Monomers	*Catalyst*	*Temp.*	*Reaction time*	*Polymer yield*[b]
		°F.	*min.*	
Styrene/vinyl triethoxysilane 1:1 molar	2% Dicup and 2% di-*t*-butyl peroxide	293	15	17% white solid
Styrene/vinyl triethoxysilane 1:1 molar	2% Dicup and 2% di-*t*-butyl peroxide	293	30	31% white solid
Styrene/vinyl triethoxysilane 1:1 molar	2% Dicup and 2% di-*t*-butyl peroxide	293	60	35% white solid
Styrene/vinyl triethoxysilane 1:1 molar	0.5% Dicup and 1.0% di-*t*-butyl peroxide	293	2160	34% white solid

[a]Bulk polymerization run without diluent; 10 g. combined monomers in 2-oz. screw-cap bottles, filled and then flushed with nitrogen before run. [b]Polymer recovered by pouring into 99% isopropyl alcohol and purified by dissolving in toluene and reprecipitating.

perature with the use of dicumene peroxide catalyst.

A blend of styrene and VTES was, likewise, tested using a range of temperatures and catalysts covering both polyester and Buton-A-500[2] polymerization conditions. The results are presented in Table II, p. 136.

It is obvious from the data of Tables I and II that the styrene is much more reactive towards the VTES than is the ethyl fumarate. The situation is complicated, of course, by the fact that styrene homopolymerizes readily under the experimental conditions, whereas fumarates do not readily homopolymerize, but copolymerize rapidly with most vinyl compounds. Since styrene constitutes 35.4% by weight of the equimolar feed with the silane, the highest yield obtained, i.e., 35%, could have been all polystyrene. However, the fact that it contained 3.6% silicon indicated that it had 37.7% of combined VTES, presumably as copolymer. The 35% yield of solid product constituted dry powdery material, so little or none of the polyvinyl triethoxysilane could be present since it would be expected to be a liquid or gummy material. Thus, true copolymerization of the styrene and VTES is indicated.

Data are presented in Table III, above, for polymerizing the styrene-VTES mixture under Buton polymerization conditions, varying the time of heating. Since the conversion to solid polymer increased only 4% from 30 to 60 min. contact time, it would appear that the styrene had been largely converted to polymers. Some of these are obviously of quite low molecular weight and are lost in the precipitation and purification steps.

The solid product from the styrene-VTES run that contained 37.7% combined silane was further purified by redissolving in toluene and reprecipitating in alcohol two additional times. The silicon content of the purified solid was only 1.2% as compared to 3.6% for that from the original precipitation. This indicates that the copolymers rich in the vinyl silane are of relatively low molecular weight. However, it is also true that such copolymers would be more soluble in the toluene-isopropyl blend than is PS.

[2]Formerly called C-oil, Buton-A-500 is a liquid copolymer of butadiene and styrene.

Effect of silane type on hydrocarbon resin to glass adhesion

Although several unsaturated silanes of the vinyl and allyl type had been investigated as coupling agents for polyester-glass fiber systems (4), it was felt that a systematic study of the different types using the more sensitive hydrocarbon resin system was justified. Also, based on the polymerization studies reported above, it appeared that a more active olefin than the $CH_2{=}CH{-}Si{\equiv}$ group might result in improved resin-glass bonding.

In an all-hydrocarbon resin system, adding the vinyl silane as its ester dissolved in the resin and employing heat-cleaned glass results in laminates of quality nearly equal to that of laminates obtained when the silane is first deposited on the glass surface in the usual manner (1). This technique offered a convenient way to test silanes.

A study was first made to determine the effect of the alcohol structure used in preparing the vinyl silicic acid ester. If the silane ester is hydrolyzed on the surface of the glass by the water adhered thereto, one would expect esters of different types and molecular weights to hydrolyze at different rates. Esters of the following alcohols were tested:

1. Ethyl alcohol, a primary alcohol.
2. Isopropyl alcohol, a secondary alcohol.
3. *t*-Butyl alcohol, a tertiary alcohol.
4. Monomethyl ether of ethylene glycol, a primary alcohol with a polar group.

Comparisons were also made with laminates obtained when no silane was added, and when a saturated type, ethyl triethoxysilane, was used.

The resin used was a 50/50 blend of Buton-A-500/vinyltoluene with 14 layers of 181 glass cloth with the No. 112 finish. Cure was for 1 hr. at 290° F. in a 0.137-in. cavity mold, followed by 16 hr. postcure in an air oven at 300° F. This is a relatively low temperature cure for this resin formulation, and was intentionally mild in an attempt to pick up differences. Data are summarized in Table IV, p. 140. It may be seen that the two simple vinyl esters gave equivalent results, whereas the A-172 type gave better over-all properties. Use of the saturated ethyl silane resulted in a laminate (To page 140)

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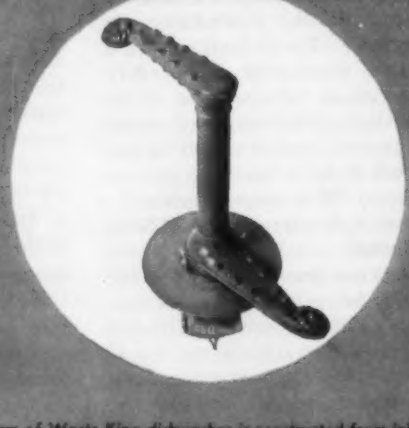

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much inferior in all physical properties to those containing a vinyl silane; in addition, it was much more opaque. It did show some improvement over that containing no silane, particularly in water resistance.

Is the A-172 better than the simple esters because it hydrolyzes more easily or because it is more highly chemisorbed on the glass surface? In an attempt to answer this question, a controlled amount of moisture was added to VTES as shown in Table V, below. Hydrolyzing the vinyl triethoxy ester either in part or completely before contacting the glass appeared to improve the effectiveness of VTES, with the exception of the long term (1 wk.) immersion in boiling water. Use of the alkaline 1% sodium hydroxide solution appeared best, and this was when enough water was added to hydrolyze all of the ester. The rapid drop in flexural strength due to the 1-wk. exposure in boiling water may have been enhanced by a wetting effect of the adsorbed sodium hydroxide.

An attempt was first made to test a series of unsaturated ethoxy silanes as coupling agents by dissolving them in the Buton-vinyltoluene blend and employing heat-cleaned glass. It soon became apparent that this technique was not applicable for comparing silanes of widely different molecular weight. Those possessing a minimum of ethoxy groups, such as vinyl dimethyl ethoxy silane, were absorbed and hydrolyzed on the glass surface to a much lower degree than the more polar vinyl triethoxysilane. Thus, it was necessary to treat the glass with the silane before contacting with the resin. The 112-glass cloth was dried in a vacuum oven at 212° F. for 1 hr. and then immersed and allowed to stand in a xylene solution of the silane acid chloride for 30 minutes. The cloth was then washed in pure xylene and allowed to air dry. It was then soaked in water to hydrolyze any residual chlorine, and again air dried. This cloth, as well as all glass cloth used in laminate preparation, was dried at 212° F. in a vacuum oven for 1 hr. just prior to lay-up. This was done to remove the variability of moisture on the glass surface.

Results from these experiments are summarized in Table VI, p. 142. It should be noted that these laminates were prepared with HG-28 type of glass cloth and cannot be compared directly with those made with the 181 fabric.

One of the most reactive groups

Table IV: Effect of silane type on 50/50 Buton vinyltoluene laminates[a]

Silane[b]	Flexural strength: At room temp.	Flexural strength: At 170° F.	Flexural strength: 24 hr. boil[c]	Time to failure in stress test in water at 170° F.[d]
	p.s.i.	p.s.i.	p.s.i.	
None	34,000	33,000	13,000	Failed under 75 lb. load
Vinyl triethoxy	49,000	41,000	40,000	1 hr., 2 min.
Vinyl triisopropyl	46,500	42,500	39,500	1 hr., 41 min.
Ethyl triethoxy	39,500	37,000	21,500	10 min.
A-172[e]	53,000	48,000	49,000	1 hr., 8 min.

[a]Recipe: 100 parts 50/50 Buton-A-500/vinyltoluene, silane as indicated, 4 parts of 50/50 Dicup/di-*t*-butyl peroxide, with 14 layers of 181 to 112 glass cloth. Cured in ⅛-in. mold for 1 hr. at 290°F., followed by a 16-hr. postcure at 300°F. [b]Vinyl triethoxysilane used 0.5 part per 100 parts of resin. Others in same molar proportion. [c]Specimens, 3 by ½ in., immersed in boiling water for 24 hr., allowed to cool in water, and tested at room temperature. [d]Specimen placed under 75 lb. load for 1 hr. and then load increased to 100 pounds. Values are for time to failure. See footnote of Table I of Reference 1. [e]Vinyl silane ester of the monomethyl ether of ethylene glycol.

Table V: Effect of hydrolyzed silane in 50/50 Buton vinyltoluene laminates[a]

Silane[b]	Flexural strength: At room temp.	Flexural strength: At 170°F.	Flexural strength: 2-hr. boil	Flexural strength: 1-wk. boil
	p.s.i.	p.s.i.	p.s.i.	p.s.i.
Vinyl triethoxy	50,000	43,000	43,500	39,500
Vinyl triethoxy[c] hydrolyzed with H_2O	56,000	45,500	52,000	39,000
Vinyl triethoxy[c] hydrolyzed with 1% NaOH	57,500	51,500	53,000	35,000
Vinyl triethoxy[d] hydrolyzed with 5% NH_3	53,500	41,500	40,500	38,500
A-172[d] hydrolyzed with 5% NH_3	51,500	41,500	41,500	33,500
A-172	53,500	48,000	46,000	39,000

[a]Recipe and cure conditions same as Table IV. [b]Used 0.5 part of vinyl triethoxysilane and 0.74 part of A-172. [c]Theoretical amount of water added to the resin-silane blend to hydrolyze all of the ethoxy groups. Water was mixed into resin by means of a high-speed mixer. [d]Enough water added as 5% ammonia solution to hydrolyze 1/6 of the ester groups. Silane pretreated before added to resin.

Table VI: Effect of silane type on 50/50 Buton vinyltoluene laminates[a]

Silane[b]	*Flexural strength* At room temp.	At 170° F.	2-hr. boil	24-hr. boil	1-wk. boil
	p.s.i.	*p.s.i.*	*p.s.i.*	*p.s.i.*	*p.s.i.*
None	30,000	21,500	12,500	12,000	12,000
136 (silane type)	45,000	36,000	41,000	42,000	43,000
Allyl trichloro	49,500	39,000	50,000	45,500	44,000
Divinyl dichloro	48,000	34,500	48,000	48,000	47,500
Phenyl vinyl dichloro	53,000	36,000	48,000	45,500	—
Methyl vinyl dichloro	47,500	34,000	42,000	40,000	40,000
Dimethyl vinyl chloro	48,000	38,500	50,000	45,000	44,500
Styrylethyl trichloro	50,000	35,000	49,500	47,000	35,000

[a]Same recipe and cure conditions as Table IV, except that 18 layers of HG-28 glass tape were used. [b]Glass cloth with the 136 finish was purchased as such. The allyl trichloride was applied as a 1.3% solution in xylene, and the other chlorides in the same molar proportion.

Table VII: Effect of drying glass at 840° F. on 50/50 Buton/vinyltoluene laminates

Silane	*Glass treatment*	*Flexural strength* At room temp.	At 170° F.	2-hr. boil	24-hr. boil	1-wk. boil
		p.s.i.	*p.s.i.*	*p.s.i.*	*p.s.i.*	*p.s.i.*
None	Standard[a]	30,000	21,500	12,500	13,000	12,000
None	840 to 930° F. at 0.025 mm. Hg[b]	35,000	24,500	16,500	14,800	16,000
A-172, 0.75%[c]	Standard[a]	44,500	32,500	35,500	36,500	31,000
A-172, 0.75%[c]	840 to 930° F. at 0.025 mm. Hg[b]	47,500	—	46,500	—	37,500
Vinyl trichloro treated						
Vinyl trichloro	Standard[a]	46,500	32,000	44,000	41,000	36,500
treated	840 to 930° F. at 0.025 mm. Hg[d]	52,000	34,500	49,000	45,500	40,000

[a]Standard glass treatment was heating at 212°F. under 10 mm. Hg vacuum for 1 hr. Cloth was exposed to atmosphere during lay-up of laminate. [b]HG-28 glass tape (112 finish) dried 4 hr. at 840 to 930°F. under 0.025 mm. Hg pressure. Cooled to room temperature under vacuum. Kept under dry nitrogen and impregnated with resin prior to exposure to air. [c]A-172 silane dissolved in resin. [d]Cooled sample of cloth was kept under nitrogen and treated with vinyl trichlorosilane in xylene prior to exposure to atmosphere.

that may be attached to the silicon atom in the silane molecule is the styryl group. Lewis and Lewis in a recent publication(5) describe the synthesis of styrylethyl triethoxysilane and its copolymerization with styrene using benzoyl peroxide catalyst at 158° F. They conclude that the styryl silyl ester polymerizes roughly four times as fast as does styrene. Vinyl trialkoxy silanes have values so low they cannot be measured when compared to styrene as 1.0.

For testing silanes containing the styryl group, a sample of styrylethyl trichlorosilane,[3] which consisted of the meta and para isomers in about 75% purity, was used. The principal impurity was stated to be ethylphenylethyl trichlorosilane. A sample of styryl triethoxy silane[4] was synthesized from monochlorostyrene via the Grignard route. Results with the styrylethyl trichloride deposited on HG-28 glass tape are given in Table VI. These and other data would indicate that use of the styrylethyl silane did not result in a stronger laminate, but rather one with inferior water resistance, based on the 1-wk. boil.

In order to determine the effect of vinyl silane concentration on coupling action, 181 glass fabric samples were obtained[5] that had vinyl silane finishes in 0.25, 0.5, and 1.0% concentrations, calculated as A-172. These were prepared using an aqueous solution of the silanol in the usual manner. When A-172 is applied as a finish to industrial glass fabric, it is understood that the usual concentration is 0.5 percent.

Laminates were prepared from the 181 cloth containing the three concentrations of silane. Results based on laminate strength and water resistance indicate no difference when using these concentrations of vinyl silane finish.

Bond of coupling agent to glass surface

The apparent lack of a major difference between the flexural strengths for the variety of unsaturated silane types tested may indicate that some other bond rather than that of the coupling agent to resin can be the weak link in the resin-glass structure. Possibly this might be the bond between the coupling agent and glass surface.

It has been shown that the glass at normal temperature and 100% relative humidity is covered with a water film calculated to be up to 180 molecules thick(6). Presumably the inner aqueous layer is strongly bound to the glass surface, whereas the outer layers are held by much weaker forces, probably hydrogen **(To page 210)**

[3]Courtesy of the Dow Corning Corp.
[4]Courtesy of Prof. E. G. Rochow, Harvard University.

[5]Courtesy of the Glass Fabrics Finishing Co.

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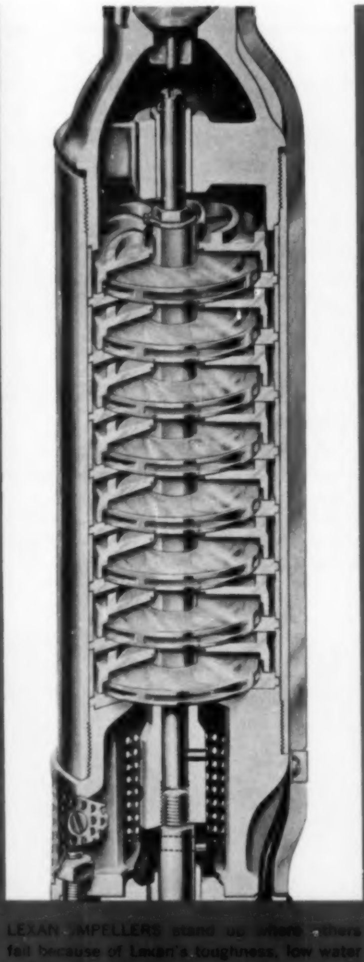

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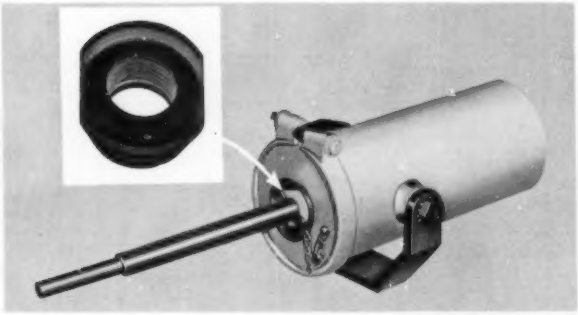
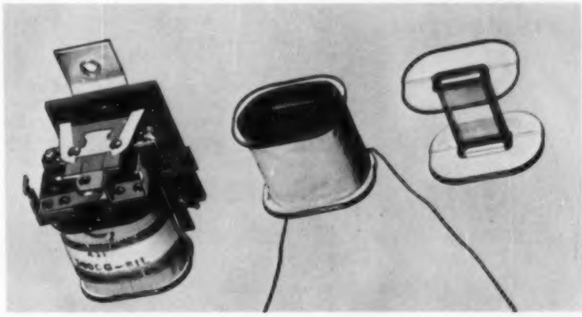
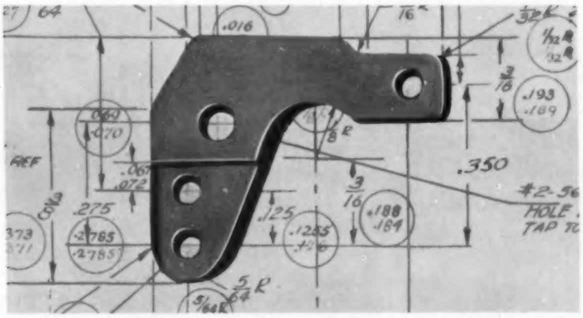


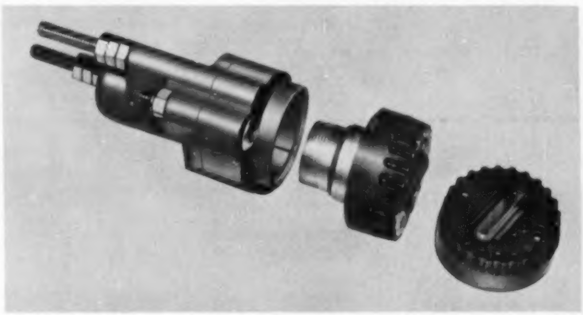
EMERGENCY-BRAKE BUSHINGS of LEXAN resin help trucks come to a safe stop. Before LEXAN bushings were used, the hole for the piston at the end of the activating cylinder quickly wore oblong, allowing road dirt to enter and cause leakage of the inner seal. The plastic's resistance to wear, heat and grease makes it ideal for this critical use. (Brake manufactured by MGM Brakes, Inc., Cloverdale, Calif. Bushings by Automatic Plastic Molding Co., Berkeley, Calif.)



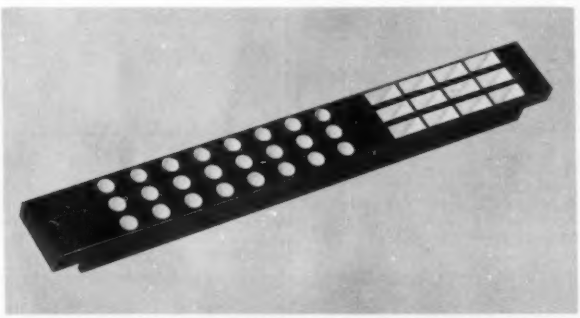
COIL FORM must not distort at temperature above 200°F under stresses caused by tightly wound wire. LEXAN resin provides heat distortion temperatures of 280-290°F under load. A good dielectric, LEXAN resin is resistant to oxidation at high temperatures and is non-corrosive even when used with very fine Class F magnet wire. (Molded for Sigma Instruments, Inc., So. Braintree, Mass. by Waterbury Companies, Inc., Waterbury, Conn.)



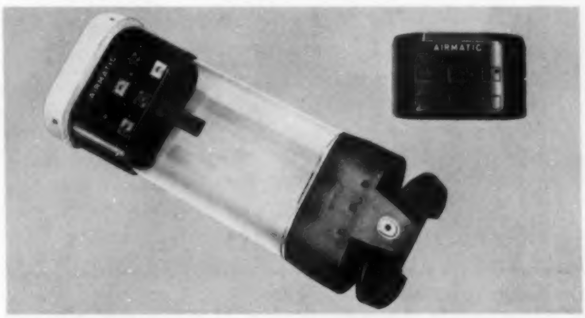
INSULATOR BLOCK of LEXAN resin helps insure trouble-free performance of electrical counter. Not much bigger than a dime, the part must maintain severe tolerances. It takes −85° to +280°F without distortion. The dimensional stability of LEXAN resin lowers cost of the part, permits replacement of materials which required costly machining to attain accurate dimensions. (Molded by Fred Knapp Engraving Co., Racine, Wis., for Abrams Instrument Corp., Lansing, Mich.)



FUSE HOLDER CAPS make use of the transparency and heat resistance of LEXAN polycarbonate resin. Lamp shining through LEXAN cover indicates blown fuse. Plastics previously used softened under the high temperature encountered in naval equipment. LEXAN resin was also selected for its good dielectric properties in the holder, which is rated up to 600 volts and 60 amps. (Molded by B&B Plastics, Oakville, Conn. and Engineered Plastics, Inc., Watertown, Conn. for Fuse Indicator Corp., Boston, Mass.)



LAMPHOLDER TERMINAL BLOCK is used inside electronic equipment where heat is difficult to dissipate. LEXAN polycarbonate resin replaced another thermoplastic which melted under severe thermal conditions. The part is molded with black resin and painted white in the lampholder holes. (Molded by Booker & Wallestad, Minneapolis, Minn. for Remington Rand Univac Div. of Sperry Rand Corp., St. Paul, Minn.)



"WARHEADS" for pneumatic tube systems take advantage of the high impact strength and dimensional stability of LEXAN resin. The good electrical properties of the thermoplastic permit placement of all electrical control elements in the head. LEXAN resin resists wear and tear and saves cost of repair and replacement in these parts, which undergo friction at speeds as high as 20 mph. (Molded for Airmatic Systems Corp., Saddle Brook, N. J. by Berkeley Engineering and Manufacturing Co., Berkeley Heights, N. J.)

PROPERTIES OF LEXAN POLYCARBONATE RESIN

PHYSICAL PROPERTIES

Property	Value	A.S.T.M. Test
Color	Light amber, transparent	—
Specific gravity	1.20	D 792
Odor	None	—
Taste	None	—
Refractive index at 25°C	1.586	—
Rockwell hardness	M70, R118	D 785
Abrasion resistance, Taber abraser with CS-17 wheel	7–11 mg/1000 cycles	D 1044
Impact strength, notched Izod, ⅛" specimen	12–16 ft-lb/in. of notch	D 256
Impact strength, unnotched Izod, ⅛" specimen	>60 ft-lb/in.	D 256
Tensile-impact	600–900 ft-lb/cu in.	—
Tensile yield strength	8,000–9,000 psi	D 638
Tensile ultimate strength	9,000–10,500 psi	D 638
Tensile modulus	320,000 psi	D 638
Elongation	60–100%	D 638
Compressive strength	11,000 psi	D 695
Compressive modulus	240,000 psi	D 695
Flexural strength	11,000–13,000 psi	D 790
Flexural modulus	375,000 psi	D 695
Shear yield strength	5,400 psi	D 732
Shear ultimate strength	9,200 psi	D 732
Light transmission (⅛ in. thick disc)	75–85%	—
Water vapor permeability	3–4 x 10^{-8} g/cm/hr/cm²/mm Hg	—
Nitrogen permeability	0.012 x 10^{-8} cc(STP)/mm/sec/cm²/cm Hg	—
Carbon dioxide permeability	0.32 x 10^{-8} cc(STP)/mm/sec/cm²/cm Hg	—
Bulk factor of pellets	1.7	—
Poisson's ratio	0.38	—
Modulus of rigidity	116,000 psi	—
Deformation under load, 4000 psi 77°F	0.2%	D 621
158°F	0.3%	
Fatigue endurance limit (Wohler method), 1800 cycles/min., 73°F, 50% RH	2000 psi	
Water absorption, 24 hr. immersion	0.2%	D 570
equilibrium 73°F	0.35%	
equilibrium 212°F	0.58%	

THERMAL PROPERTIES

Property	Value	A.S.T.M. Test
Heat distortion temperature	264 psi: 280°–290°F 66 psi: 283°–293°F	D 648
Mold shrinkage	0.005–0.007 in./in.	D 955
Thermal conductivity	4.6 x 10^{-4} cal/sec/cm²/°C/cm	—
Coefficient of linear thermal expansion	3.9 x 10^{-5} in./in./°F	D 696
Flammability	Self-extinguishing	D 635
Brittle temperature	<−135°C	D 746
Specific heat	0.30	Bulletin 157

Deformation under load on 0.5 in. cube (A.S.T.M. Test D 621)

Temp., °F	Load, lb	Deformation, %
158	1000	0.282
158	500	0.080
77	1000	0.220
77	500	0.101

ELECTRICAL PROPERTIES

Property	−30°C	−3°C	23°C	100°C	125°C	A.S.T.M. Test
Dielectric constant, 60 cycles	3.12	3.14	3.17	3.15	3.13	D 150
Dielectric constant, 10^6 cycles			2.96			D 150
Power Factor, 60 cycles	0.005	0.004	0.0009	0.0009	0.0011	D 150
Power Factor, 10^6 cycles			0.010			D 150
Volume resistivity, ohm-cm	$>10^{17}$	$>10^{17}$	2.1 x 10^{16}	2.1 x 10^{15}	2.7 x 10^{14}	—
Arc resistance, stainless steel strip electrodes			10–11 sec			D 495
Arc resistance, tungsten electrodes			120 sec			

Property	25°C	100°C	A.S.T.M. Test
Dielectric strength, short time	3,910 v./mil at 1.5 mils 3,080 v./mil at 3.0 mils 2,560 v./mil at 4.7 mils 1,130 v./mil at 23.0 mils 400* v./mil at 125.0 mils	3,380 v./mil at 3.0 mils 1,250 v./mil at 23.0 mils 600* v./mil at 125.0 mils	D 149
Resistance to electron beam radiation	No change up to 5 x 10^7r dosage		

(*The step-by-step values are essentially the same as the short time values for the 125-mil pieces)

Chemical Materials Department, Section MP-2
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Behavior of plastics in re-entry environments—Part 2

By Donald L. Schmidt*

In this, Part II of a two-part article, the author discusses the thermal parameters indicative of the modes by which ablative materials absorb and dissipate heat. These modes include: mass transfer in the boundary layer, radiative transport, phase transitions, chemical reactions, convection in the liquid layer, and internal conduction and storage by the solid material. Guidelines useful in the selection and optimization of plastics intended for thermal protective systems of missile and satellite re-entry vehicles are also analyzed.

Part I (MPl, Nov. 1960, pp. 131-140) described the important physicochemical aspects of the process of ablation and the critical material and environmental variables upon which the ablative performance of plastics materials depends. Tables I and II, Figures 1 through 7, Equations 1 to 4, and References 1 through 18, were published as parts of Part I. Table I is repeated here for the reader's convenience.

Ablation of plastics is essentially a heat and mass transfer process in which a large amount of thermal energy is expended by a sacrificial loss of surface material. In the process, heat is absorbed, dissipated, and generated by the following mechanisms: internal conduction and storage by the solid body, convection in the liquid layer if one exists, phase transitions, mass transfer in the boundary layer, radiant energy transport, and chemical reactions (19).[1] The magnitude of these terms varies for different materials and environments.

Internal heat conduction

When heating starts, the plastic responds solely as a heat sink. All the energy absorbed at the surface is conducted internally and stored by the effective heat capacity of the material. Energy transport from the surface proceeds at a low rate, however, due to the characteristic low thermal diffusivity of the plastic. Consequently, the surface temperature rises rapidly and the process of ablation is initiated. The ablation process is non-steady state, however, and the rate of heat penetration into the material exceeds the rate of surface removal. After transient heating equal to

$$t_{ss} = \alpha \left(\frac{\rho_b H_{eff}}{q_o} \right)^2 \sim \alpha \left(\frac{1}{V_w} \right)^2 \qquad \text{Eq. 5}$$

where

t_{ss} = time to reach steady-state ablation and

α = material thermal diffusivity, the surface temperature remains constant and the ablative process is essentially in quasi-steady state (20). At this point, the velocity of surface recession has been stabilized, and is approximated by

$$V_w \sim \frac{q_o}{\rho_b H_{eff}} \qquad \text{Eq. 6}$$

If the body is assumed to be semi-infinite, radiation opaque, and homogeneous with constant thermal properties, its temperature distribution may be expressed as

$$k \left(\frac{d^2 T}{dy^2} \right) = C_p V_w \rho_b (dT/dy) \qquad \text{Eq. 7}$$

where

k = thermal conductivity of the material,

T = temperature,

y = coordinate normal to the surface, and

C_p = material specific heat.

From Eq. 7, the temperature distribution within the material at steady-state conditions is exponential and expressed as

$$T_{ss} = T_b + \Delta T e^{-V_w y/\alpha} \qquad \text{Eq. 8}$$

where $\alpha = k/C_p \rho_b$, or

$$T_{ss} = T_b + \Delta T e^{-y/\theta} \qquad \text{Eq. 9}$$

where $\theta \sim k/C_p V_w \rho_b$.

For Eqs. 8 and 9,

T_b = temperature of intact, non-heated material,

ΔT = difference temperature $(T_w - T_b)$,

T_w = interface of ablative temperature, and

θ = thermal layer thickness for ΔT.

In reality, the internal temperature distribution in an ablating plastic is very complicated, due to the presence of chemical reactions, degradative products, substrate gases, phase transitions, and similar factors. Thus, it becomes necessary to determine the internal temperature distribution by experimental means. Representative steady-state temperature distributions in two ablating composite plastics are illustrated in Fig. 8, p. 149.

The rate of internal heat transfer and storage by the solid body is also a matter of practical importance. At the surface (y = 0), the rate of internal heat transfer is approximated by

$$q \sim C_p \Delta Tm \qquad \text{Eq.10}$$

and the rate of energy stored in the thermal layer per unit surface area is

$$q_{sp} \sim C_p \Delta T \rho_b V_w \qquad \text{Eq. 11}$$

Clearly then, heat storage by the solid body will be appreciable only at high numerical values of

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[1] Numbers in parentheses denote references at the end of the article, p. 198.

specific heat, density, ablative velocity, and temperature rise in the material. These requirements, however, are incompatible with the thermal insulation and weight restrictions imposed on ablative materials. Minimum values of internal temperature rise are necessary to protect the internal components of the vehicle. A low-density value is required to stay within the critical weight and bulk limitations of a re-entry heat shield. Finally, the ablative velocity must be small to prevent significant changes in geometric configuration, which could influence the aerodynamic characteristics of the vehicle. These factors, together with the low heat absorptive ability of solid ablative materials (generally less than 10% of the incident flux), tend to make this particular process a relatively inefficient means of expending energy.

Convection in liquid layer

Plastic composites containing inorganic inclusions undergo melting, and the viscous melt appears on the surface as a film, droplets, or irregular globules. A fraction of the molten material is vaporized and the remainder is removed mechanically by the aerodynamic forces. This latter liquid transport mechanism is known as "convection in the liquid layer." In the process, heat is physically removed from the ablating surface by being transported in the hot melt to another location. The amount of heat transferred in the liquid layer for these materials is small when compared to that obtained by vaporizing the melt. For this reason, convection of mass in the liquid layer is not desired unless to maintain a smooth surface of constant geometric configuration.

Phase transitions

In response to heating, plastics may undergo phase changes such as depolymerization, fusion, vaporization, and sublimation. Energy is absorbed in these endothermic processes, the amount depending upon the chemical and physical structure of the material components, their final products of decomposition, and their environmental influence.

Important thermal reactions of an ablating plastic will now be discussed, using polytetrafluoroethylene as a representative ma-

List of symbols

Symbol	*Definition*
A	Frontal area, ft.^{2}
C_D	Drag coefficient
C_p	Material specific heat, B.t.u./lb.–°F.
e	Exponential value
f	Fraction of ablated material that vaporizes
g	Gravitational acceleration, 32.2 ft./sec.^{2}
h	Energy absorbed or liberated, B.t.u./lb.
H	Enthalpy (heat content), B.t.u./lb.
H_{eff}	Effective heat of ablation, B.t.u./lb.
$\overline{H}_{eff}$	Thermochemical heat of ablation, B.t.u./lb.
ΔH	Enthalpy potential across boundry layer, with no vapor injection (H_s–H_w), B.t.u./lb.
J	Joule's constant or mechanical equivalent of heat, 778.2 ft.–lb./B.t.u.
k	Thermal conductivity, B.t.u.–ft./ft.^{2}–sec.–°F.
m	Mass ablative rate ($\backsim \rho_b V_w$), lb./ft.^{2}–sec.
M	Mean molecular weight
N	Transpiration number
q	Heat transfer rate, B.t.u./ft.^{2}–sec.
R	Vehicle nose radius, ft.
t	Unit of time, sec.
T	Temperature, °F.
ΔT	Difference temperature (T_w–T_b), °F.
u	Flight velocity, ft./sec.
V_w	Velocity of surface recession, ft./sec.
W	Weight, lb.
y	Coordinate normal to the surface, ft.
Y	Transpiration factor
(g)	Gas phase
(l)	Liquid phase
(s)	Solid state
α	Thermal diffusivity ($k/C_p \rho_b$), ft.^{2}/sec.
ε	Emissivity
θ	Thermal layer thickness ($\backsim k/C_p V_w \rho_b$), ft.
ρ	Density, lb./ft.^{3}
σ	Stefan-Boltzmann constant, 4.81×10^{-13} B.t.u./ft.^{2}–sec. (°Rankine)^4
Y	Transpiration factor
Δ	Difference value
$\backsim$	Approximate value
Subscripts	
a	Undissociated air
b	Intact nonheated material
c	Chemical reaction
cp	Energy storage rate in the solid body, B.t.u./ft.^{2}–sec.
cw	Cold-wall value
dp	Depolymerization
f	Fusion or melting value
g	Injected gaseous species
i	Interface value, with mass transfer but no combustion
L	Laminar flow
lh	Heat of physical change
o	Non-ablating value at ablative temperature
r	Radiant emission rate, B.t.u./ft.^{2}–sec.
s	Stagnation point conditions
ss	Steady-state value
st	Standard velocity, 26,000 ft./sec.
T	Turbulent flow
tc	Boundary layer cooling by gaseous injection
w	Solid-gas or liquid-gas interface
1	Air density at standard conditions, 0.0804 lb./ft.^{3}
∞	Free stream conditions ahead of shock wave
Superscript	
η	Transpiration coefficient

terial. When the highly crystalline linear polymer is heated, it undergoes several order-disorder transitions. The first two transitions occur at 68 and 86° F. with the absorption of about 4 B.t.u./lb. (21). A sharp first-order transition is subsequently initiated as the temperature approaches 620° F., at which point the polymer changes into an amorphous, transparent, and rubbery substance. It is then said to be melting, although a liquid phase is not readily apparent. The energy expended in the process is the heat of fusion h_f, and for polytetrafluoroethylene, the value is about 37 B.t.u./lb. (22).

With a further increase in temperature to about 750° F., the polymer slowly depolymerizes into its monomer C_2F_4 and other fluorine-containing compounds. Energy expended by this phase change is the heat of depolymerization h_{dp}. The value is both temperature and pressure dependent, since these environmental factors influence the molecular weight of the decomposition products. The heat of depolymerization is of the order of 658 to 688 B.t.u./lb., based on available thermochemical data. These values were computed for temperature conditions ranging from 680 to 1,125° F. and equilibrium vapor pressures of 0.059 to 760 mm. of Hg (23).

The total heat required to vaporize polytetrafluoroethylene under steady-state ablation, then, is given by

$$h = C_p \Delta T + h_f + h_{dp} \qquad \text{Eq. 12}$$

which can be solved numerically by the proper choice of requisite values. For the purpose of illustration, the polymer will be considered to remain in the solid state as it is heated from room temperature to 800° F. The material is assumed to depolymerize and completely vaporize. If

$T_w = 800°$ F.,
$T_b = 75°$ F.,
$C_p = 0.27$ B.t.u./lb.-°F.,
$h_f = 37$ B.t.u./lb., and
$h_{dp} = 680$ B.t.u./lb.,

then the total energy absorbed by heat capacity plus phase changes is about 913 B.t.u./lb. This theoretical value compares favorably with an experimental value of 750 B.t.u./lb., which was obtained by ablating polytetrafluoroethylene in an air arc heater (5).

Ablative plastic composites containing inorganic reinforcing agents also absorb a significant amount of heat by phase changes. To illustrate, consider the properties of quartz (silica) fibers. In undergoing melting, the siliceous fibers absorb about 90 B.t.u./lb. Subsequent vaporization and dissociation of the molten silica occurs with an attendant high endotherm of the order of 5,500 B.t.u./lb. (24). Theoretically, then, the thermal efficiency of plastic composites containing quartz fibers should be very high provided the viscous melt is largely vaporized, rather than mechanically removed.

This desirable behavior of quartz has been confirmed experimentally in many high-temperature environments (12, 15).

Boundary layer cooling

Gaseous species formed in the ablation of plastics diffuse through the hot boundary layer and absorb heat in the process. The boundary layer is thus increased in thickness and its original temperature gradient greatly distorted. Consequently, less heat is transferred from the environment to the ablating surface and less material is ablated. Furthermore, the continual flow of gaseous products from the surface changes the velocity gradient in the boundary layer and reduces the shear stresses acting on the material's surface.

Boundary layer cooling by gaseous injection has been examined theoretically and experimentally by numerous investigators (25 to 34). From their work, a relation has been derived to express the rate of energy dissipation q_{to} for conditions of laminar flow. This relationship is given by

$$q_{to} = fm\,(Y_L\,\Delta H) \qquad \text{Eq. 13}$$

where $$Y_L = N\,(M_a/M_g)^{\eta} \qquad \text{Eq. 14}$$

and

f = fraction of degraded material that vaporizes,
Y_L = transpiration factor for laminar flow,
N = transpiration number,
M_a = molecular weight of undissociated air,
M_g = average molecular weight of injected gaseous products, and
η = transpiration coefficient.

If the thermodynamic and transport properties of the injected gases are assumed equal to those of air, Eq. 13 becomes

$$q_{to} = fm\,[0.67\,(29/M_g)^{0.25}\,\Delta H] \qquad \text{Eq. 15}$$

From Eq. 15, it may be seen that

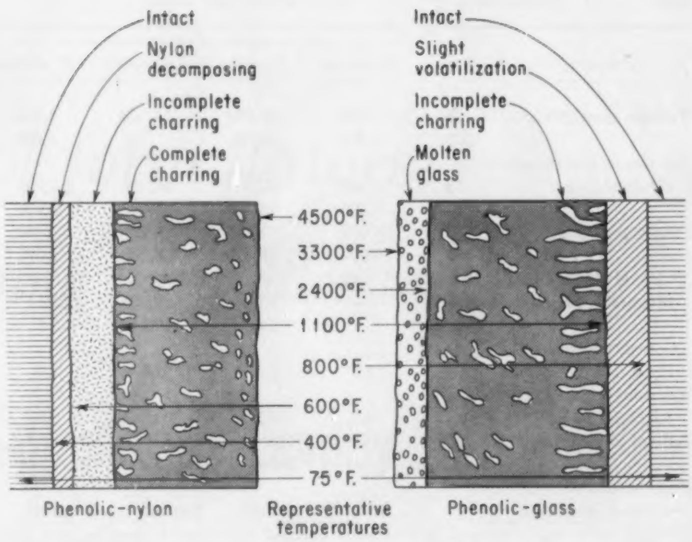

FIG. 8: Temperature distribution in two plastics during steady-state ablation.

Table III: Variation in properties with orientation of reinforcement (18); phenylsilane-resin silica-fabric laminate

Property	*Temp.*	*Orientation of reinforcement*			
		Random	*Parallel*	*End-grain*	*20° shingle*
	°F.				
Tensile strength, p.s.i.	75	6,000	23,200	1,500	4,500
	500	2,900	21,000	750	3,100
Columnar compressive strength, p.s.i.	75	12,000	37,200	60,000	7,700
	500	5,200	16,500	35,400	5,700
Flexural strength, p.s.i.	75	15,000	49,100	5,100	7,300
	500	9,000	26,700	2,600	5,500
Flexural modulus of elasticity, 10^6 p.s.i.	75	—	2.3	0.7	1.1
	500	—	1.8	0.1	0.7
Thermal conductivity, B.t.u./hr./°F./ft.^{2}-in.	—	2.0	2.0	6.0	2.9
Thermal expansion coefficient, 10^{-6}/°F.	—	8.0	6.3	25.9	9.9
Rate of ablation	High	Fair	Good	Excellent	Excellent
	Moderate	Good	Poor	Excellent	Excellent
Post-ablative surface condition	—	Smooth	Rough	Smooth	Smooth

CORRECTION: Table III was inadvertently omitted from Part I. Because of a typographical error, reference to it (in the section subheaded "Orientation of reinforcement," beginning on p. 134 of the Nov. issue) appeared as a reference to Table II, elsewhere in Part I.

boundary layer cooling is at a maximum when vaporization of the ablated material is complete. Subliming plastics like PTFE and PE, then, should exhibit good ablative performance.

Maximum cooling effect is also obtained when the gaseous products of ablation are of low molecular weight. Hydrogen gas having the lowest molecular weight has the highest potential for absorbing heat. This property of the gas along with its high thermal diffusion coefficient offers a partial explanation for the characteristically high boundary layer cooling associated with plastics ablation.

Lastly, the boundary layer cooling effect increases linearly with the enthalpy gradient and is most effective at high enthalpies.

Since the major portion of a re-entry vehicle surface may experience turbulent flow conditions, mass transfer cooling in turbulent boundary layers is a matter of practical importance. This complex subject, however, is not well understood. From experimental work conducted (34 to 36), it appears that the transpiration factor for turbulent flow Y_T is approximated by:

$$Y_T \sim 0.33\, Y_L \qquad \text{Eq. 16}$$

when the molecular weight of the gas is comparable to that of air. Nevertheless, turbulent flow increases the vaporization of a liquid layer and thereby raises the amount of energy absorbed by the heat of vaporization term. More research is necessary to provide a thorough knowledge of transpiration cooling effects in turbulent boundary layers.

Radiant energy transport

Radiation is a principal mode of energy transport in most ablative plastics. Heat is radiated from hot ablating surface to the surroundings in an amount depending upon the surface temperature level and emittance. Energy may also be radiated internally and subsequently attenuated by the material components.

Total thermal emission from an ablating surface is given approximately by the well known Stefan-Boltzmann fourth power law

$$q_r \sim \epsilon\sigma\, T_w^4 \qquad \text{Eq. 17}$$

where

q_r is the rate of emission of a non-black body of emissivity,

$\varepsilon\sigma$ is the Stefan-Boltzmann constant, and

T_w is the ablative surface temperature.

This relation indicates that energy dissipation by radiative emission becomes appreciable only at high values of surface temperature and emissivity.

Radiant emission from an ablating plastic produces an apparent increase in the material thermal efficiency. This is illustrated by the following relation:

$$H_{eff} = \frac{C_p\, \Delta T + h_{th} + fm\,(Y_L\, \Delta H)}{1 - (q_r/q_o)} \qquad \text{Eq. 18}$$

in which the effective heat of ablation value increases as the radiant emission rate becomes a larger fraction of the incident heating rate. However, radiation affects the entire ablation process and the magnitude of the effect is imperfectly understood.

Plastics that are radiation opaque are highly desirable, since they 1) absorb radiation from the hot boundary layer, 2) prevent internal radiative transport, and 3) emit a portion of the incident flux absorbed at the surface.

The amount of thermal energy dissipated by radiant emission varies greatly with various plastics. Organic plastics such as polyethylene, nylon, and polytetrafluoroethylene attain maximum ablative temperatures of the order of 1,400° F. Thus, they are able to dissipate only a relatively small amount of heat by surface radiation. Composite plastics that form a glassy surface melt during ablation reach appreciably higher ablative temperatures, which are in the range of 3,000 to 4,300° F. These high temperatures coupled with relatively high surface emittances permit appreciable energy dissipation, as shown in Fig. 9, p. 152. A maximum surface radiation is obtained from plastics that form a surface char by carbonizing in response to heating. For these ablative materials, various surface temperatures up to the sublimation temperature of carbon (6,600° F.) may be obtained during hyperthermal exposure.

High surface temperatures of ablating plastics are also desirable from the standpoint of reducing the enthalpy potential across the boundary layer. As the ablative temperature is increased, less heat is transferred to the exposed surface of the material. Consequently, the mass rate of ablation is decreased.

Many composite plastics form

surface residues during ablation that are semi-transparent to radiation. Therefore, these ablators experience additional energy flow into the substrate material. The internal temperature distribution is thus altered, which in turn may greatly affect the ablative rate (13,14).

For example, vitreous fiber reinforcements form a surface melt having a viscosity that is strongly temperature dependent. As energy is transferred internally, the surface temperature is depressed and the melt viscosity near the surface is increased greatly. The melt is thus less susceptible to aerodynamic shear forces of the gas stream, and a greater fraction of the liquid vaporizes. Increased vaporization expends additional energy by the heat of vaporization term, increases the mass transfer cooling effect, and tends to further reduce the shear stresses acting at the gas-liquid interface.

Internal radiation, then, tends to decrease the mass rate of liquid removal from the surface and produce an apparent increase in the heat of ablation value. However, as mentioned earlier, internal radiation may increase the thickness of substrate material that is required for insulative purposes.

Chemical reactions

Recently, attention has been focused on heterogenous chemical reactions of plastics ablation. Combustion of surface material during ablation liberates heat and increases the surface heating rate. Likewise, oxidation of ablative species in the hot boundary layer increases the enthalpy of the environment, and may possibly increase the heat transferred to the ablating surface. The net effect of these exothermic reactions is to produce an increase in the mass rate of ablation and a reduction in the material thermal efficiency.

Plastics that carbonize during re-entry heating are particularly susceptible to the effects of oxidative combustion. For these types of materials, the principal mode of surface removal may be a diffusion-controlled oxidative process, and not a result of heat transfer. Oxidation of the carbonaceous surface takes place in a five-step process:

1) Convection and diffusion of reactants to the surface,

2) Physical and chemical adsorption,

3) Chemical reaction,

4) Desorption of the combustive products, and

5) Counter-diffusion and convection of the products into the boundary layer (10).

In its simplest form, the reaction may be stated as:

$$C(s) + 1/2\ O_2\ (g) \rightarrow CO\ (g) + h_c \qquad \text{Eq. 19}$$

with the formation of carbon monoxide. Energy released in the process is 3,960 B.t.u. per pound of carbon consumed. The product gas diffuses into the boundary layer and may undergo further reaction according to:

$$CO(g) + 1/2\ O_2\ (g) \rightarrow CO_2\ (g) + h_c \qquad \text{Eq. 20}$$

to form carbon dioxide. Additional energy is released by the chemical reaction in the amount of 4,340 B.t.u. per pound of consumed carbon monoxide.

Surface combustion in laminar and turbulent flows has been examined by several investigators (10, 37 to 44). From their work, it may be concluded that surface combustive heating of ablating plastics generally produces only minor thermal effects during reentry. Energy released by the combustive reactions (heat of combustion) is at least partially balanced by the absorption of heat by product gases as they leave the general vicinity of the ablating surface.

Ablative gaseous species diffuse into the hot boundary layer, and if reactive, undergo exothermic oxidation. The heat liberated in the process serves to increase the total enthalpy of the environment, which may or may not affect the surface heating rate of the ablating material.

To illustrate, consider the case in which polytetrafluoroethylene monomer C_2F_4 diffuses into the boundary layer and chemically reacts according to the equation:

$$C_2F_4\ (g) + O_2\ (g) \rightarrow 2COF_2\ (g) + h_c \qquad \text{Eq. 21}$$

to form carbonyl fluoride, with possible intermediates of CO_2 and CF_4. The amount of heat liberated by the combustive reaction is about 10,230 B.t.u. per pound of oxygen taking part in the reaction

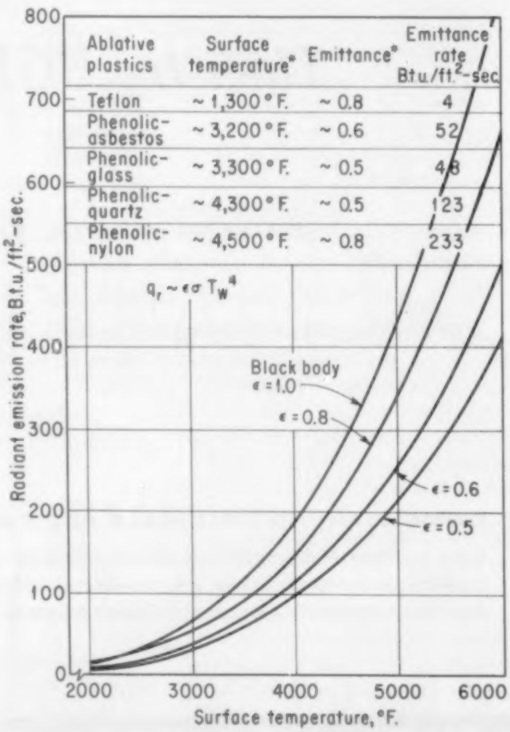

FIG. 9: Radiant emission rate of various ablating plastics as functions of temperature and emissivity. (Asterisks at top of graph denote approximate value for air plasma exposure.)

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(22). The increase in surface heating by the exothermic reaction for air containing 21% oxygen is, therefore:

$$\Delta q = q_i\,(0.21\, h_e/\Delta H) \qquad \text{Eq. 22}$$

provided all of the oxygen diffusing into the boundary layer is completely reacted with combustible vapors. Since the mass rate of vapor injection is generally high during re-entry ablation, it appears likely that the reaction shown in Eq. 21 is controlled by the rate of oxygen diffusion into the boundary layer. Therefore, Eq. 22 represents an upper limit for the increase in surface heating by combustion in the boundary layer.

Fig. 10, below, illustrates the reduction in thermal efficiency of polytetrafluoroethylene as a result of combustive heating in the boundary layer. This plot gives the theoretical and experimental variation in the heat of ablation of the polymer as a function of the enthalpy potential across the boundary layer. For the case of no boundary layer combustion of the monomer:

$$\overline{H_{eff}} = 915 + 0.49\,(\Delta H) \qquad \text{Eq. 23}$$

with negligible surface radiation from the ablating material. For conditions of total combustion of monomer vapor in the boundary layer, the equation is:

$$\overline{H_{eff}} = \frac{915}{1 + (2{,}150/\Delta H)} + 0.53\,(\Delta H) \qquad \text{Eq. 24}$$

again neglecting radiant emission from the material's surface. A comparison of these theoretical relations with experimentally determined values in Fig. 10 indicates that gas-phase reactions in the boundary layer are important only at low enthalpy potentials. For the range of enthalpies associated with re-entry and satellite vehicles, combustive heating of gaseous products in the boundary layer can be neglected.

Summary and conclusions

An analysis has been presented of the important physico-chemical and heat and mass transfer aspects of ablation, which may occur during interaction of plastics with re-entry environments.

Plastics absorb and dissipate a prodigious amount of thermal energy when exposed to hyperthermal re-entry environments, and thereby afford heat protection to the vehicle structure. Up to several thousand B.t.u.'s are expended in ablating a pound of plastic.

There is no single "best" ablative plastic, since performance varies critically with both material and environmental parameters. However, the ablative performance of a given composite material can be tailored to the environment by altering the individual material components and construction.

The efficiency of ablative plastics increases with the severity of the thermal environment. Therefore, there is no upper practical limit to the temperature and aerodynamic heating of re-entry environments in which these materials can be used.

Re-entry environments involving high laminar-heating require plastics that will sublime or gasify to a high degree. This mode of behavior is required because of the high mass-transfer cooling obtained by vapor injection into the hot boundary layer. Most plastics in the gaseous state expend as much as 5,000 B.t.u./lb. in being transported through a very high temperature boundary layer. Thus, organic resins such as polyethylene, polytetrafluoroethylene, and nylon appear attractive for this type of re-entry application.

Re-entry environments involving high turbulent heating require plastics composites that possess a high rate of mass vaporization and a high heat of vaporization. Reinforcing fibers such as quartz and silica offer considerable promise in this respect, since they may expend up to about 1,700 B.t.u./lb. in boundary-layer cooling and 5,500 B.t.u. per pound in vaporizing.

Low-temperature plastic ablators having a low thermal conductivity are optimum for satellite re-entry environments involving moderate aerodynamic heating of long-time duration. Noncarbonizing plastics such as polyethylene and polytetrafluoroethylene appear very attractive for these applications.

Carbonizing plastics are effective heat dissipators in re-entry environments involving very high aerodynamic heating rates. Combinations such as phenolic-nylon form a surface char of high temperature and emittance in this type of environment, and thus are able to radiate a large portion of the incident flux.

The effective heat of ablation value (material thermal efficiency) is an increasing function of stagnation enthalpy (flight velocity), and tends to decrease with an increase in the stagnation pressure (altitude) or chemical reactivity of the environment. This performance value is dependent upon body size when the ablation process is kinetically controlled or surface radiation effects are large. From the expository thermal **(To page 198)**

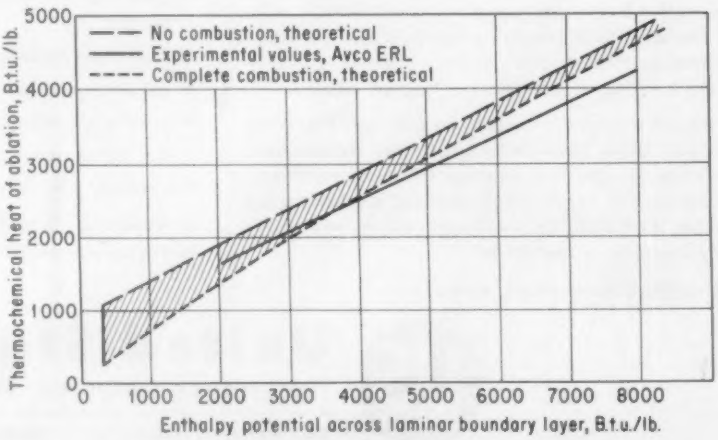

FIG. 10: Effect of combustion in the boundary layer on thermochemical heat of ablation of polytetrafluoroethylene.

Special report:

Tenth meeting of ISO/TC 61 committee on plastics

Oct. 17-22, 1960, Prague, Czechoslovakia

The 10th meeting of Technical Committee 61 on Plastics of the International Standardization Organization (ISO/TC 61) was held in Prague, Czechoslovakia, on Oct. 17-22, 1960. Fifteen countries were represented by 112 delegates and observers as follows: Czechoslovakia, 17; France, 12; Germany, 12; Hungary, 3; Italy, 13; Japan, 2; Netherlands, 3; Poland, 4; Rumania, 3; Sweden, 9; Switzerland, 8; United Kingdom, 8; United States, 12; U. S. S. R., 4; Yugoslavia, 2.

The U.S. delegation, appointed by the American Standards Assn., consisted of W. E. Brown, Leader (Dow Chemical Co.); Robert Burns, chairman of the 10th Meeting (Materials Advisory Board, National Research Council); C. L. Condit, Secy. of the 10th Meeting (S.P.I.); H. C. Gunst (Union Carbide Plastics Co.); A. E. Hafner (Naugatuck Chemical Co.); G. M. Kline (National Bureau of Standards); N. A. Skow (Synthane Corp.); A. C. Webber (Du Pont); P. E. Willard (Food Machinery & Chemical Corp.); G. H. Williams (Bell Telephone Laboratories); R. K. Witt (Johns Hopkins U.); and E. Y. Wolford (Koppers).

The nine Working Groups held 18 sessions and treated approximately 40 of the items currently listed on the program of work of ISO/TC 61.

Five Draft ISO Recommendations were revised editorially and are now ready for submission to the ISO Council for approval and publication. They pertain to 1) standard atmospheres for conditioning and testing plastics, 2) determination of the melt flow index of polyethylenes, 3) compression molding test specimens of thermoplastic materials, 4) injection molding test specimens of thermoplastic materials, and 5) compression molding test specimens of thermosetting materials.

Three new Draft ISO Recommendations were approved for circulation to the ISO Member Bodies for letter ballot. They describe methods for the determination of stiffness properties of plastics as a function of temperature by means of a torsional test, tensile properties, and determination of maximum temperature and rate of temperature increase during the setting of polyester resins.

Five Draft Proposals were prepared for consideration by the ISO/TC 61 Member Bodies. They relate to determinations of 1) percentage of monomer and low molecular weight polymer in polyamides, 2) relative viscosity of polyamides, 3) water content of polyamides, 4) resistance to changes in color caused by natural light (second draft), and 5) change of mechanical properties after contact with chemicals (second draft).

Committee has prepared 40 standards

Four ISO Recommendations prepared by ISO/TC 61 were published during the past year, bringing to nine the total of ISO Recommendations pertaining to plastics. Fourteen Draft ISO Recommendations have been printed and are expected to be approved by the ISO Council for promulgation this year. Four Draft ISO Recommendations approved at the 1959 meeting in Munich are in the process of review and balloting by the ISO Member Bodies. Thus, some 40 international standards have reached a preliminary or final form during the first 10 years of operation of ISO/TC 61, representing the cooperative efforts of plastics engineers from 21 participating countries. Included among these documents is a list of over 800 equivalent terms in English, French, and Russian, soon to be augmented by the equivalents in other languages.

Progress of 9 working groups at Prague

Working Group 1 on Nomenclature and Definitions initiated the preparation of a supplementary list of equivalent terms and definitions for some 100 terms relating to materials. The IUPAC document on abbreviations will be reviewed and comments compiled for consideration at the 1961 meeting. Swiss Standard VSM 77200, P.1 and F.1-F.8, concerning the fabricated forms and general properties of plastics, will be examined by the Working Group to determine its suitability as an ISO standard.

Working Group 2 on Mechanical Properties is continuing its development of proposals for the determination of impact strength, modulus of elasticity in flexure, and compressive properties. Methods for testing plastics with the torsion pendulum, tensile testing of thin films, and determination of indentation hardness are to be prepared. The group will also examine national standards for universal testing machines and statistical processing of test data with a view to arriving at appropriate international standards.

Working Group 3 **(To page 194)**

NEW DEVELOPMENTS

Many minds at work on new ways to use plastics, new designs, and new product concepts offer ideas you can use.

Fabric decoration without printing

A new technique for applying patterns and textures to a wide range of fabrics by production-line methods—but without the expense of costly engraving rolls or heavy fabric-printing equipment—has been demonstrated at North Carolina State College's School of Textiles, Raleigh, N. C. The process, developed by B. F. Goodrich Chemical Co., Cleveland, Ohio, was shown on production-scale spraying equipment donated to the school by Binks Mfg. Co., Chicago, Ill.

In the process, liquid plastisol is sprayed on textiles in abstract swirls, random line, or spatter designs. On heating in an oven, the vinyl fuses to the fabric in permanent patterns or textures that are said to withstand washing and dry cleaning; the patterns, it is also claimed, will not essentially alter the fabric's hand. The plastisols used were prepared by Flexible Products Co., Marietta, Ga., using BFG Chemical's Geon.

Fabrics prepared in this manner are now being considered for use in automobile interior trim, draperies and curtains, upholstery and slip-cover materials, tickings, and a wide range of garments.

Patterns may be varied by adjusting the spray guns, altering the flow properties of the plastisol, and by changing the number of spray heads, their position, or the speed of the material through the equipment.

Patterns may also be varied by using equipment with moving guns.

The amount of material used varies with the design and averages 0.5 to 1 oz. per sq. yd. of fabric.

Styrene for check protector

A simple device for writing checks and, at the same time, for protecting them against fraudulent alterations consists of a ball point pen with a roller attachment at one end and a base-plate, both molded of Monsanto Chemical Co. polystyrene. The check protector is made by Hamilton-Pax Inc., Chicago, Ill.

Molded into the base plate, which measures 6⅛ by 2⅝ in., are 1120 tiny pyramids. Molded into the roller, which is ⅜ in. in diameter, are 48 corresponding cavities, so that when the roller is passed over the plate, the pyramids mate with the cavities. To protect a check, it is placed on the plate and the roller drawn across its face. The result is a perforated area on the check the width of the roller, which effectively prevents any alteration. Retail price of the Registrar check protection, including the gift box, is $3.98.

Molds, made by Lend Plastics Products Inc., Chicago, Ill., have four cavities for the roller and four for the base plate.

Epoxy glass upgrades tube design

A switch to epoxy glass tubing for insulating and mechanical components has enabled Jennings Radio Mfg. Co., San Jose, Calif., to upgrade design features on several models of over-current relays and switch mounts made by the company. The tubing is Phenolite Grade G-11-3681, epoxy resin-bonded glass fabric-base material (NEMA Grade G11), made by National Vulcanized Fibre Co. Jennings uses it in place of solid phenolic rod as insulation between high- and low-voltage points. It is much lighter than phenolic rod, yet has equal or better mechanical and electrical properties, the company states.

Although epoxy resin glass-base laminates are more expensive pound for pound than phenolic laminates, Jennings reports that the cost of their tubing is actually lower than the phenolic rod they had been using. This is because the overall weight is much less. Price of rolled G-11-3681 epoxy glass tubing in a typical size of 1-in. I.D. by $\frac{1}{16}$-in. wall thickness is approximately $1.70 per linear foot when ordered in maximum quantities.

(More on page 162)

DOW | RESINS

BRINE LOSES ITS BITE

When "reefer" hatch covers are preform moldings

Refrigerator car hatch covers take a beating from weather, hard use, and corrosive brine. Preform molded polyester hatch covers prove they can take it, and save money for the user, as well!

The Plastics Division of General American Transportation Corporation preform molds the durable hatch covers shown above for Standard Railway Equipment Manufacturing Company. The results are economical covers with excellent resistance to weathering and to the attack of salt; they won't warp or lose their strength and they last the life of the car with little or no maintenance.

Reinforced polyester moldings are low in cost, too. Nearly any configuration can be molded, greatly reducing the number of costly production operations normally required by other materials.

Preform moldings offer advantages in cost, in production ease, in long life under difficult service conditions; and the types of products for which they can be used are virtually unlimited. The Dow Chemical Company supplies the basic monomers for polyester resins for premix, preform and mat moldings—Dow styrene and Dow vinyltoluene.

For information on these Dow monomers, write THE DOW CHEMICAL COMPANY, Midland, Michigan, Plastics Sales Department 1967CS12.

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Now better than ever . . . Egan's famous "Willert Temperature Control System," which gained world-wide acceptance in the thermoplastics extrusion field for its uniform thermal regulation, regardless of viscosities or melt temperatures!

The heart of the new Willert System is its AIR COOLED CONDENSERS, which are constructed of high pressure finned tubing and are mounted within the cylinder covers of the extruder. Automatically controlled blowers are mounted in the base (see photo at lower right).

Egan Extruders equipped with the improved patented Willert Temperature Control System automatically dissipate excessive frictional heat. The result is closer tolerance extrusions at greatly increased outputs.

Egan Extruders with the new Air Cooled Willert System are available in sizes from 2" through 12", with L/D ratios of 20:1, 24:1, 32:1.

DESIGN AND GENERAL CONSTRUCTION

With this system, each individual zone along the cylinder is jacketed. The jacket is formed by a series of circumferential grooves, connected by channels on the top and bottom, with steel sleeves welded on the outside. An air cooled reflux condenser assembly is connected to the top of each jacket and a condensate return line connects the vapor pressure chamber and the bottom of cylinder. All joints, with the exception of the vent valve and filler plug, are welded to eliminate the possibility of leaks. Each zone is a completely closed system.

Heater bands are mounted around the steel jackets.

Each cylinder section is filled with a liquid heat transfer medium, which has a relatively flat vapor pressure vs. temperature range curve (water for temperatures up to 465° F and Dowtherm A for temperatures from 350° to 700° F are used), and, upon initial heat-up, the system is vented to remove air and noncondensable gases.

OPERATION AND COMPARISON

As the cylinder is heated, a vapor pressure, corresponding to the temperature of the cylinder or the heat transfer medium is maintained within the pressure chamber. The liquid will not boil as long as this pressure is maintained.

If cooling is required, due to a build-up of frictional heat or possibly due to a desire to lower the temperature in the zone, the thermocouple, which is located in the cylinder close to the liner, senses the excessive heat, and activates the blower. This, in turn, condenses some of the vapor, reduces the pressure and thus the liquid in the jacket begins to boil. The condensate returns to the bottom of the cylinder, setting up a circulating system.

Since only the latent heat of vaporization is removed, the vapor and the condensate are of essentially the same temperature; consequently, the control is gradual, producing no shock cooling to the cylinder, but removing the excessive heat most efficiently. The design of the jacket is such that the cooling takes place over the full length and full circumference of each zone, thereby eliminating any possibility of thermal distortion. There are no hot or cold spots.

SUMMARY OF ADVANTAGES

1. Completely automatic.
2. Completely self-contained.
3. No manually operated valves or switches.
4. Heating or cooling is uniform over full length and circumference of each zone.


The Egan Extruder illustrated below is a 4½" model with 24:1 L/D ratio.
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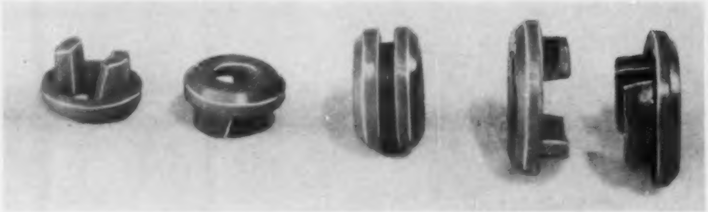
 (From page 158)

Indestructible bucket

An injection molded nylon materials-handling bucket that is lower in cost than commonly used standard steel types (although exactly how much lower the company will not reveal) has been introduced by Frazier & Son, Clifton, N. J. Made of Du Pont Zytel 101, the bucket measures 10 in. long, 6 in. wide, and 3½ in. high; wall section is 11 mils. The buckets, which according to the company have been approved by the New York Board of Health for food handling, are said to meet sanitary requirements for conveying all types of free and semi-free flowing products, such as pharmaceuticals, candy, tobacco, seed, and small hardware. The buckets are standard equipment in Frazier Whiz-Lifter elevator feed conveyors. With 60 to 70 buckets required for a typical installation, the application could develop into a fairly substantial market.



SNAP-TOGETHER GROMMETS, which are molded of PE, not only cost less than their rubber counterparts, but also outperform them.

PE grommets

Two-piece, snap-together grommets, molded of Alathon-10 (Du Pont) polyethylene, are easier to insert, have better dielectric characteristics, and show superior resistance to chemicals and oils encountered in the electronics industry than standard rubber units—but cost no more.

Grommets are produced by G. G. Budwig, San Diego, Calif., on a Simplomatic Little Giant air operated automatic. Molds have 16, 20, and 24 cavities, all fed simultaneously, and gating is "submarine." Parts are stripped from the gates and runners upon ejection. Resin used has a melt index of 2.1 and a density of 0.923.

Plastic pipe for better smoking

To most smokers, the thought of a plastic pipe may at first seem preposterous. But they'll have a quick change of heart after sampling Pyro-Bol, an essentially all-plastic pipe produced by Pyro-Bol Corp., Chicago, Ill.

Of radically different design from conventional briars, the new pipe consists of a nylon stem, a nylon-filled outer bowl and retaining ring, and a melamine base for an inner bowl. A Kimax glass bowl (Owens-Illinois, Kimble Glass Co.) screws into the melamine base and holds the tobacco while the pipe is smoked. (For a close-up of the various parts, see photo below.)

The outer bowl, separated into cooling fins, is compression molded of 50% nylon-filled melamine in multi-cavity molds. It consists of three parts: two case halves and a top retaining ring. The two halves, which fit around the glass bowl, are held together by two small hinges of spring steel. The top retaining ring locks into a molded-in slot along the top of the bowl halves. The effect of this construction is that the pipe can be easily taken apart and put together in seconds to facilitate cleaning the bowl.

NOVEL PIPE (inset) is all plastic, except inner glass bowl and hinges holding outer bowl together. Plastics pipe parts are nylon stem; nylon-filled melamine inner bowl base; melamine outer bowl, with cooling fins; and melamine retaining ring.

Among the major advantages of the new pipe construction is the good heat dissipation achieved by the cooling fins molded into the outer bowl; light weight—total weight is 1¼ oz.; smooth smoking (no breaking-in is required, no irritation is reported); and it affords a comfortable bit.

Suggested retail price (displayed in a styrene box and with sample of tobacco) is $6.00.

All plastic components are produced by M. R. Plastics Research Inc., Salamanca, N. Y. The black stem is injection molded of Spencer 401 nylon-6 in multi-cavity molds. The inner bowl base is compression molded of American Cyanamid's #3136 glass-filled melamine, in multi-cavity molds; threads into which the glass bowl screws are molded-in. A tubular projection at one end fits into the nylon stem.

For the present, this is the only model being produced. The company's yearly sales aim is 1 million pipes to smokers, of whom there are between 10 and 16 million in the United States today.

(More on page 167)

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A good film to consider is that extruded from medium-density Tenite Polyethylene. Such film is clear, glossy and invitingly soft. This last property is particularly advantageous where you would like to have your product's basic softness fully conveyed to a prospective customer. (Bread and textile items, for example, have scored outstanding sales successes when wrapped in film of Tenite Polyethylene.)

While the film is soft to the touch, it possesses just the right degree of stiffness and slip for efficient use on high-speed packaging machines, where its wide heat tolerance also simplifies heat-sealing operations and minimizes waste. Its resistance to puncture and tearing is excellent, and this toughness helps protect the wrapped merchandise against damage and soiling during handling by shoppers. Other useful properties include high resistance to moisture-vapor transmission and the ability to take and hold whatever printed decoration you wish to apply over your package.

Film of Tenite Polyethylene is available from leading extruders across the nation. Look into its many advantages as a protective and sales-building wrapper, bag or pouch for your products. For more information on its over-all packaging usefulness, write EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENNESSEE.

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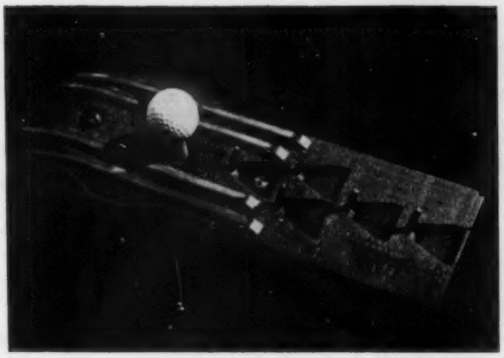

Polyethylene golfing aid improves swing

Thanks to a molded polyethylene practice device, golfers will be able to keep the form of their swing during the winter months.

The device, named the Dow Finsterwald Golf Swing Indicator, consists of a platform, 6 by 15 in., on which is mounted a flexible tee and five free-to-rotate pins. The platform is molded by Warren Molded Plastics Inc., Cortland, Ohio, from Marlex high-density PE supplied by Phillips Chemical Co.

The flexible tee, which is also made of high-density polyethylene, is assembled to the platform from the rear side—which forms a ball socket—and is held in place with a vinyl cup that is snapped into the bottom side of the platform and held by an undercut.

The indicator, marketed by T & C Enterprises Inc., can be used with or without ball to analyze a golfer's swing. Depending on the position of the pins, the golfer can tell whether he hit correctly or whether he hooked, sliced, smothered, pushed, or failed to follow through. In a perfect swing, the face of the club will flatten all the pins in a straight line of flight. A hook or slice will deflect the pins to the left or right, respectively. The pins are reset with a few taps of the club head. The unit retails for $6.95 list.

Polystyrene clothing boxes

Clear and opaque polystyrene materials are combined in a new line of injection molded boxes for clothing and shoes. The boxes provide visibility of contents and protection from dust.

Sliding drawers with molded-in pull handles are produced in either a clear transparent shade or a transparent augmented by tiny metal-foil flakes. The opaque box frames are available in pink, blue, yellow, or aqua colors.

The boxes, made by Stuart M. Lerner Inc., Melville, N. Y., come in two sizes, 7 by 12½ by 4 in. for shoe storage, and 11 by 15 by 4 in. for lingerie, sweaters, or shirts. Newest addition to the company's line is a 12 by 12 by 8½ in. hat box, which features unique transparent pull-open doors.

Frames and drawers of the two smaller boxes are molded by Lerner in single cavity molds on a 12/16-oz. H.P.M. machine. The hat box components are produced in two cavities on a 20-oz. Impco machine. Dylene polystyrene for this application is supplied by Koppers Co. Inc., Pittsburgh, Pa.

The boxes are ribbed at top and bottom to permit stacking without slipping, thus giving a "chest of drawers" appearance. Retail prices are $1.69 for the shoe box (or $5 when ordered in quantities of three), $2.98 for the lingerie box, and $3.98 for the hat box.

MOLDED BOXES for storage of shoes and clothing have frames of opaque polystyrene, drawers of transparent PS. Drawers are opened by molded in pull handles.

(More on page 168)

Polycarbonate coil

One of the tiniest plastic electrical components ever machined on a production line basis with automatic lathe equipment is a minute coil form for a solenoid safety switch on a warning light circuit for jet aircraft. The part, measuring 0.725 in. in length with flanges of 0.325-in. diameter and 0.100-in. thickness at either end, is machined in one piece of ½-in. extruded Merlon (Mobay Products Co.) polycarbonate rod stock by W. S. Shamban & Co., Culver City, Calif.

The part replaces a metal form which had also been machined of rod stock to the same dimensions. The polycarbonate part, however, eliminates the need for coating the form for electrical insulation and corrosion resistance. It is made by the Grimes Mfg. Co., Urbana, Ohio.

. . . And in brief

- Keeping up to date with the latest fashion trends in executive-type briefcases, Rimar Co., New York, N. Y., is now fabricating attaché cases completely of vinyl. Retail list price of the units is $2.98; size is 16¼ by 10¾ by 3¼ inches. Weight is about one-third that of equivalent leather cases, and priced as much as 10 times lower. The cases are fabricated of vinyl sheet supplied by Sommers Plastics Products Co., E. Rutherford, N. J., by electronic welding using a Thermatron 15-kw. unit.

- Polypropylene throttleable gate valves in sizes from ½ to 2 in. with socket-weld, flanged, or screwed ends, are now available from Vanton Pump & Equipment Corp., Hillside, N. J. Valves are said to resist most solvents, greases, oils, and the majority of common acids at temperatures up to 185° F.

- Removable rayon-acetate label introduced by the Avery Label Co., Monrovia, Calif., as FAB K-3, grips firmly to a wide variety of surfaces, is said to adhere smoothly on curved and spherical surfaces.

- Difficult-to-package military and commercial products are now shipped in molded rigid urethane foam packages, covered with cotton or fibrous glass cloth to give added strength and resistance to surface abrasion. Called AeroGard, they are custom molded by Aerojet-General Corp., Azusa, Calif., a subsidiary of The General Tire & Rubber Co. The density of the foam is generally 2 lb./cu. ft., but may be altered to meet special load-bearing requirements.—End

FRENCH

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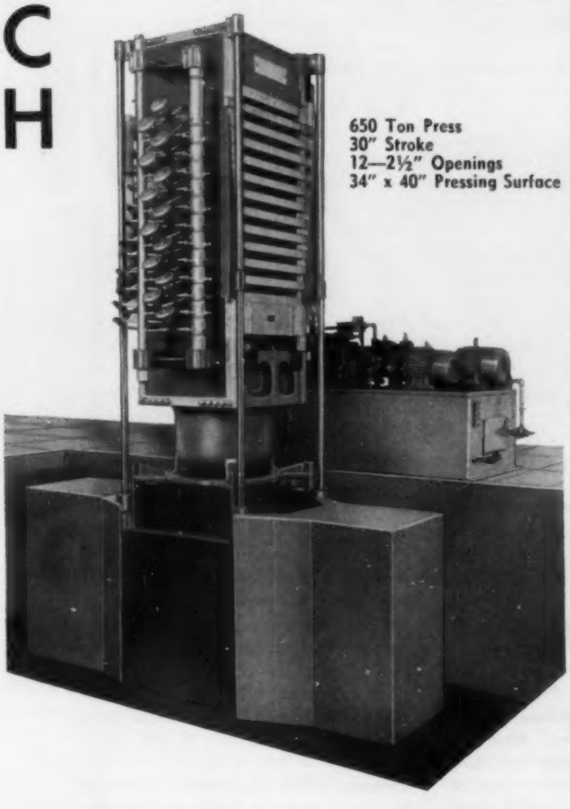

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LITERATURE

Write for these publications to the companies listed. Unless otherwise specified, they will be sent gratis to executives who request them on business stationery.

Reinforcements. "Uniglass Fabrics" describes a line of industrial glass fabrics that can be combined with natural or synthetic resins to form rigid or flexible reinforced plastics. Handbook illustrates the fabrics, weaves, and finishes available; gives a variety of industrial applications; discusses various molding processes; includes directory of plastic and resin producers. 30 pages. *United Merchants Industrial Fabrics, 1407 Broadway, New York 18, N. Y.*

PVC resins for plastisol compounding. Formulations available, advantages, uses, etc., for a line of polyvinyl chloride resins for rotational molding. 4 pages. *Naugatuck Chemical Div., United States Rubber Co., 1230 Ave. of the Americas, New York 20, N. Y.*

Plasticizers. Properties of plasticizers, test data, suggested uses, etc., for Development Polyester 430. 3 pages. "Plasticizers for PVC" shows how the molecular structure of diester and polyester plasticizers is related to the physical properties of the plasticizers themselves and to the physical properties of plasticized PVC. Technical Bulletin 6. 40 pages. *The Geigy Co. Ltd., Rhodes, Middleton, Manchester, England.*

Tetrahydrofuran. Properties, uses, product information, etc., for tetrahydrofuran (THF), a solvent used in the plastics-fabricating and chemical industries. 14 pages. *E. I. du Pont de Nemours & Co. Inc., Wilmington 98, Del.*

Fibrous glass-RP paneling. Specifications, uses, etc., for a cross-corrugated fibrous glass-reinforced plastic panel material, which is available in 50-ft. rolls, 40 in. wide, and in 2½- by 9/16-in. corrugations, with crinkle finish on both sides. 8 pages. *Filon Plastics Corp., 333 N. Van Ness Ave., Hawthorne, Calif.*

Expandable polystyrene. Facilities for molding expandable PS; variety of applications possible; properties; etc. 6 pages. *Weber Plastics Inc., Stevens Point, Wis.*

Films, rods, tubes, sheets, blocks. Catalog and price list for this company's line of these plastics materials. 66 pages. *Cadillac Plastic and Chemical Co., 15111 Second Ave., Detroit 3, Mich.*

Phenolics. Grades and specifications, recommended molding procedures, laminate properties, and other technical data for Poly-Preg phenolic impregnations for the plastics industry. 5 pages. *U. S. Polymeric Chemicals Inc., Stamford, Conn.*

Plastic Foams—Storage, Handling, and Fabrication is the latest safety guide published by this association. Safety Guide 5. Price: 20 cents. *Manufacturing Chemists' Assn. Inc., 1825 Conn. Ave., N. W., Washington 9, D. C.*

Design inserts. Bulletin describes a pre-printed method of decorating low-pressure fibrous glass molded products. These Chromold design inserts are printed on saturating-type papers suitable for insertion in the mold with the glass preform and the resin. Includes samples. 4 pages. *E. F. Twomey Co. Inc., 728 W 10th Place, Los Angeles 15, Calif.*

Shipping and storage containers. Features, uses, etc., for a line of Invert-A-Bin shipping and storage containers for handling flowable dry products. Available in 36-, 65-, and 88-cu.-ft. sizes, the bins hold up to 4000 pounds. 4 pages. *The Powell Pressed Steel Co., Hubbard, Ohio.*

Spray mask washing machine. Specifications, uses, features, etc., for small spray mask washing machine, which is used for the cleaning of masks used in the spraying of small parts. Brochure W-2025. 2 pages. *Conforming Matrix Corp., 364 Toledo Factories Bldg., Toledo 2, Ohio.*

Adhesives, coatings, and sealers. Uses, characteristics, properties, etc., for a line of over 170 of these products. Cross-reference index lists over 200 different adhesive, coating, and sealer applications. 12 pages. *Adhesives, Coatings, and Sealers Div., Minnesota Mining & Mfg. Co., 900 Bush Ave., St. Paul 6, Minn.*

Diisocyanates. History, chemistry, uses, etc., for diisocyanates. Bulletin also describes how these materials are combined with others to form urethanes, which find uses as adhesives, coatings, molding compounds, fibers, foamed resins, etc. 8 pages. *Allied Chemical Co., National Aniline Div., 40 Rector St., New York 6, N. Y.*

Porous Teflon and Kel-F. Pore size, mechanical properties, chemical resistance, flow capacity, available thicknesses, etc., for a line of porous Teflon and Kel-F. 4 pages. *Porous Plastic Filter Co. Inc., 30 Sea Cliff Ave., Glen Cove, N. Y.*

Vinyl. "Quality Plastics for Quality Products" gives properties, applications, chemical resistance, etc., for a line of Geon vinyls, Estane polyurethane materials, and Abson ABS materials. 18 pages. *B. F. Goodrich Chemical Co., 3135 Euclid Ave., Cleveland 15, Ohio.*

Professional Activity Groups—Your Opportunity to Grow Professionally in Plastics outlines the function, advantages, organization, and operation of these groups; indicates scope and activities of each of the 15 currently organized groups. 16 pages. *Society of Plastics Engineers, 65 Prospect St., Stamford, Conn.*

Production Techniques for Vacuum Forming Thermoplastic Sheets outlines new developments in processing technology, materials, and equipment. Includes 50 illustrations and graphs; list of equipment suppliers. Bulletin 1092. 30 pages. *Monsanto Chemical Co., Plastics Div., Springfield 2, Mass.*

Testing U.S.A. describes a line of machines and test methods available for plastics, paper products, textiles, etc. 4 pages. *Testing Machines Inc., 72 Jericho Turnpike, Mineola, N. Y.*

A Plastics Institute for America. Brochure answers the questions: "Why is such an institute needed;" "What will it do;" "Who will benefit;" and "How will it be supported?" 14 pages. *Plastics Institute Committee, 30 Charlton St., Princeton, N. J.*

Fire prevention. "Fire Safe Electrical Installations for Hazardous Locations in the Plastics Industry" discusses fire hazards and recommends ways of preventing them. 5 pages. *The Society of the Plastics Industry Inc., 250 Park Ave., New York 17, N. Y.*—**End**

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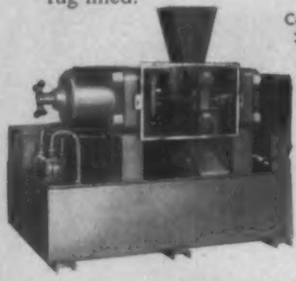

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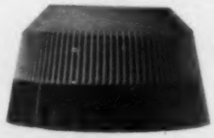

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Film

(From pp. 75-79)

100-ft.-dia. Echo satellite, made of metallized Mylar polyester film, was launched into a 1000-mile orbit around the earth. The Mylar skin which enclosed the satellite is only ½-mil thick, yet it withstands the temperatures to which it will be subjected—from below freezing to 240° F.—without losing its tensile strength.

But once the premise is accepted that the plastics films have much in their favor for use as a structural element, what avenues of application are open to the designer? Some of the answers are obvious and are already commercial: inflatable temporary warehouses and storage depots, waterproof boat sails, tents, glazing for storm windows, or movie projector screens fabricated of polyester film; "air houses" that can be used to thaw out a building site or for enclosing an entire house while construction is in progress are in the making.

The less obvious answers to where and how to use plastics films, however, are the ones that strike the imagination. What about using polyester film, for example, to create leakproof ducting? Five years ago, an industrial designer might have laughed at the concept. Today, the Boeing 707 and 720 jet airliners make use of polyester bags (fabricated of Minnesota Mining & Mfg. Co.'s Scotchpak) to eliminate air leakage from the cabin walls and to provide heat control and air distribution. Simply heat sealing the bags to rigid polyethylene stampings provide the ultimate in fast as well as very economical installations.

Or how about polyester film "spring-back" shelving that keeps grocery stack displays stable and attractive, eliminates loose plywood or cardboard dividers, and simplifies stacking. Heat-set in coiled form, the polyester film (in this case, Mylar) uses its "plastic memory" to automatically roll back to each succeeding carton as the forward carton is taken off —until it finally rolls up out of sight when the last package in the layer is lifted off.

The possibilities are virtually endless. Tensile strengths of some of the plastics films are high. Mylar polyester film has a range from 17,000 to 23,700 p.s.i.; polypropylene film, from 4500 to 10,000 p.s.i.; cellulose acetate film, from 7000 to 13,000 p.s.i.; Kel-F, from 6300 to 6600 p.s.i.; and polyvinyl chloride film, from 7000 to 10,000 p.s.i. Terafilm polyester film approximately 18,000 p.s.i.; and Teslar polyvinyl fluoride film, from 14,000 to 18,000 p.s.i. (per mil basis, measured on average two-mil film).

The concept of film as a virtually "invisible shield" that can be formulated to keep out moisture or gases or light or corrosion or heat—or any combination thereof —has opened sizable markets. Polyethylene film in agricultural applications, for example, makes a superior mulch film that shuts out the sun's rays; as coverings it can save farms up to \$2.50/ton of silage by excluding air and moisture; as greenhousing "glaz-

ing" it is replacing conventional materials.

In the construction industry, an estimated market of some 35 million lb. of polyethylene film by 1963 is expected to take in such applications as: moisture vapor barriers and waterproofing membranes for concrete; overlay blankets for curing concrete; enclosures for buildings under construction; or temporary coverings for all types of construction equipment and materials.

Also into the construction market goes some 30 million lb. of vinyl film a year for such uses as: moisture vapor barriers in built-up roof decks; facings for fibrous glass insulation used for roofing, flashing materials under windows and doors, and decorative coverings.

In the area of industrial tanks, shipping drums, and containers, the corrosion resistance of plastics film liners are already well known.

Taking off from these established applications, manufacturers have ventured into new areas:

- Bags fabricated from heat-sealable metallized polyester film (Scotchpak from Minnesota Mining & Mfg. Co.) are being used by a Harvard medical researcher to capture expired air of hospital patients for scientific analysis. The large bags are attached to a rubber hose which is in turn connected to a mask placed over the mouth of the patient. As the air is expired, it is collected inside the bag, and taken to the laboratory for metabolic study. Reasons for selecting the 2-mil film: its long wearing qualities, ease of handling, and, above all, its excellent resistance to permeation by gases. Scotchpak's permeability to oxygen and to air, respectively, is 4.5 and 14.0 (cc./100 sq. in./24 hr. at 1 atm.).
- One firm has applied polyethylene film (Durethene, by Koppers) as a vapor barrier for air-conditioning ducts. Using a 1500-ft. roll of tubular film, the installer gradually works the tubes onto the ducts until the ducts are completely covered.
- A metallized polyester film (from Minnesota Mining & Mfg. Co.), with extra protection against all types of vapors and gases, is now being used as a bladder for the lining of a variety of fuel apparatus.
- Inertness, heat sealability, weatherability, and excellent temperature stability of FEP-fluorocarbon film (from Du Pont) is used in the fabrication of fuel cells and bladders for such cryogenic materials as liquid oxygen and hydrogen and corrosive chemical propellants such as hydrazine.
- Currently in the works is an experimental evaluation of clear polyethylene film (Durethene, by Koppers) as a seal over stoppings in coal mines. About 100 ft. of film is used for each stopping to limit air leakage and to direct vital air currents to the working face.
- In a take-off on the use of protective linings for industrial storage tanks, polyethylene film (from Kordite Co.) is now being used in the fabrication of plastic bags tailored for hospital refuse-disposal. The bags are water-tight, easily closed, and can be incin-

erated without reopening. Reported cost: less than paper!

Film as a carrier, as separator

What can film carry? For one thing, it can carry an adhesive on one side. When it does, it becomes a pressure-sensitive or permanent tape that can serve industry today in a hundred and one different ways. Reportedly, there are over 300 such tapes (based on acetate, vinyl, polyethylene, polyester, or fluorocarbon materials) available today to serve for protection, labeling, coding, sealing, bundling, splicing, holding, edging, decorating, and masking.

And it is far from the end. Some of the newer films have yet to get going. In the works, for example, is a fluorocarbon tape (based on Du Pont's Teflon and supplied by Minnesota Mining & Mfg. Co.) that is used in one instance as a covering for rollers and drums to eliminate build-up problems and in another instance as a chemically-inert tape to seal and permanently lubricate pipe joints.

But if a plastic film tape can carry adhesives on one face, it can carry them on the other as well. The result: a double-coated tape useful for difficult detailed work such as holding padding to recessed edges, adhering plates to press-stereotypes, fastening small objects to plant layout boards, and holding upright small parts, such as glass vials, during manufacturing operations.

And here's a new wrinkle: using a thermoplastic film by itself as a bonding agent that can fuse into the opposing faces of the two parts to be bonded. American Motors, for example, is using the technique to join together the two halves of the phenolic-glass sections that make up the headliner for one of its 1961 models. The film in this case is a 3-mil high-density polyethylene. Polyethylene film as a binder also figures in one other application reported in the development stage: a foam-to-fabric bond.

But if film can carry an adhesive, it can also carry gold leaf for hot-stamping operations . . . or it can carry a magnetic oxide coating to function as magnetic sound tape . . . or carbon for carbon paper applications (polyester film is already commercial in this application) . . . or ink for typewriter ribbons (a polyethylene film ribbon, priced at $12.50 per doz., is in use by IBM Corp. and is said to produce more accurate print than does the fabric ribbon).

Once the premise is established, the variations are infinite. One manufacturer uses polyester film as a carrier for flake mica in insulation systems where corona or high temperatures are a problem.

As a repellent, plastics films are also firmly established: Polyvinyl alcohol films are already widely in use as release agents in molding reinforced plastics. Polyethylene sheets are used extensively as separator sheets between layers of "camelback" during tire building operations in the rubber industry. Polyester film has already shown its potentials as an excellent release for sticky products in conveyor applications. Even oriented styrene film (in this case, Trycite by Dow) has

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PART	MATERIAL	WGT. (grams)	MOLD CAVITIES	CYCLE TIME
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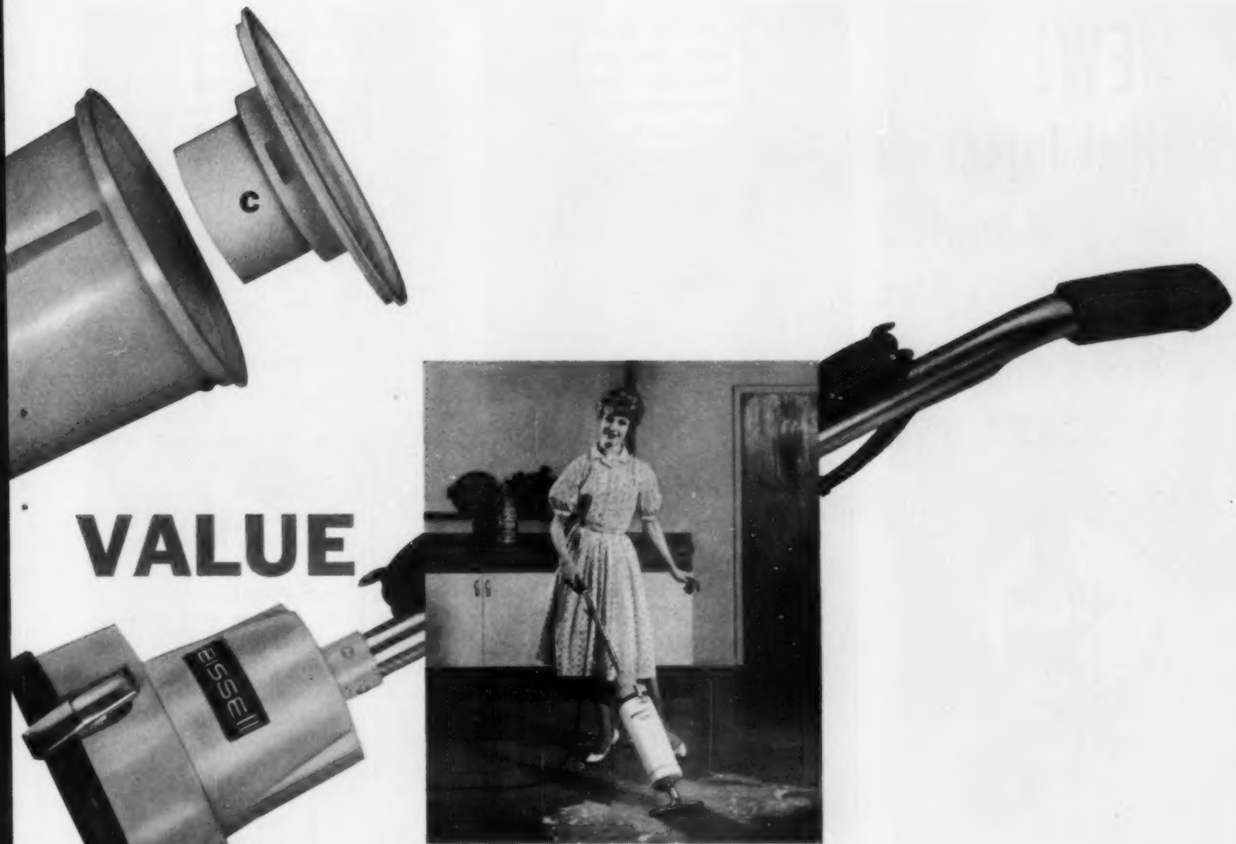
B. Scrub Master inner tank	Styron 475	176.4	1	28 sec.
C. Scrub Master separator lid	Styron 475	55.4	2	32 sec.
D. Sweep Master tank	Styron 475	403.4	1	53 sec.
E. Sweep Master nozzle	Bakelite TNDA 2100	118	2	59 sec.
F. Sweep Master collar	Linear Polyethylene	8.9	4	32 sec.



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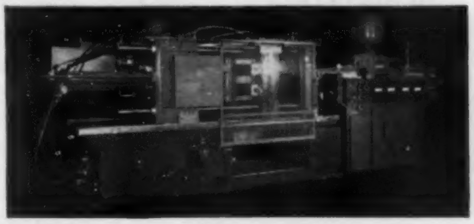

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injection molding equipment

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found use as slip sheets between pages of paint color books.

More recently, two of the newer films—polyvinyl fluoride and FEP-fluorocarbon—have also come into the picture. PVF is already under evaluation as a release sheet for most materials (with the exception of the silicones which require curing cycles that are said to tax the film's thermal stability).

FEP-fluorocarbon film has also proved out as extremely effective at temperatures up to 250° C. While comparatively new to molding applications, it has already been put to use as a release sheet for one-shot polyurethane molding and in molding silicones at temperatures from 175 to 250° C. Du Pont also expects potential use for its new cementable FEP-fluorocarbon film as ice-release coatings on aluminum trays and as release cladding on heated or chilled processing rolls.

Film as a surfacing material

As a surfacing material, plastics films can lend many of their unique attributes to more conventional materials. Acetate, vinyl, and PE film laminate surfaces are already well known.

And their potential seems to grow every day. Only recently, for example, Minneosta Mining & Mfg. Co. announced that its Thermofax copying machines have been adapted to permit polyester film to be fed directly into the machine and laminated under heat and pressure to cards or papers. One manufacturer reports that by using this system, he can laminate job process cards (on one side only) at a cost of only 4¢ per card. Prior to the use of the protective laminate surface, the manufacturer reported that the cards required a 38% replacement after each job. At an estimated replacement cost of 49¢ per card, the loss in a year's time became a substantial figure.

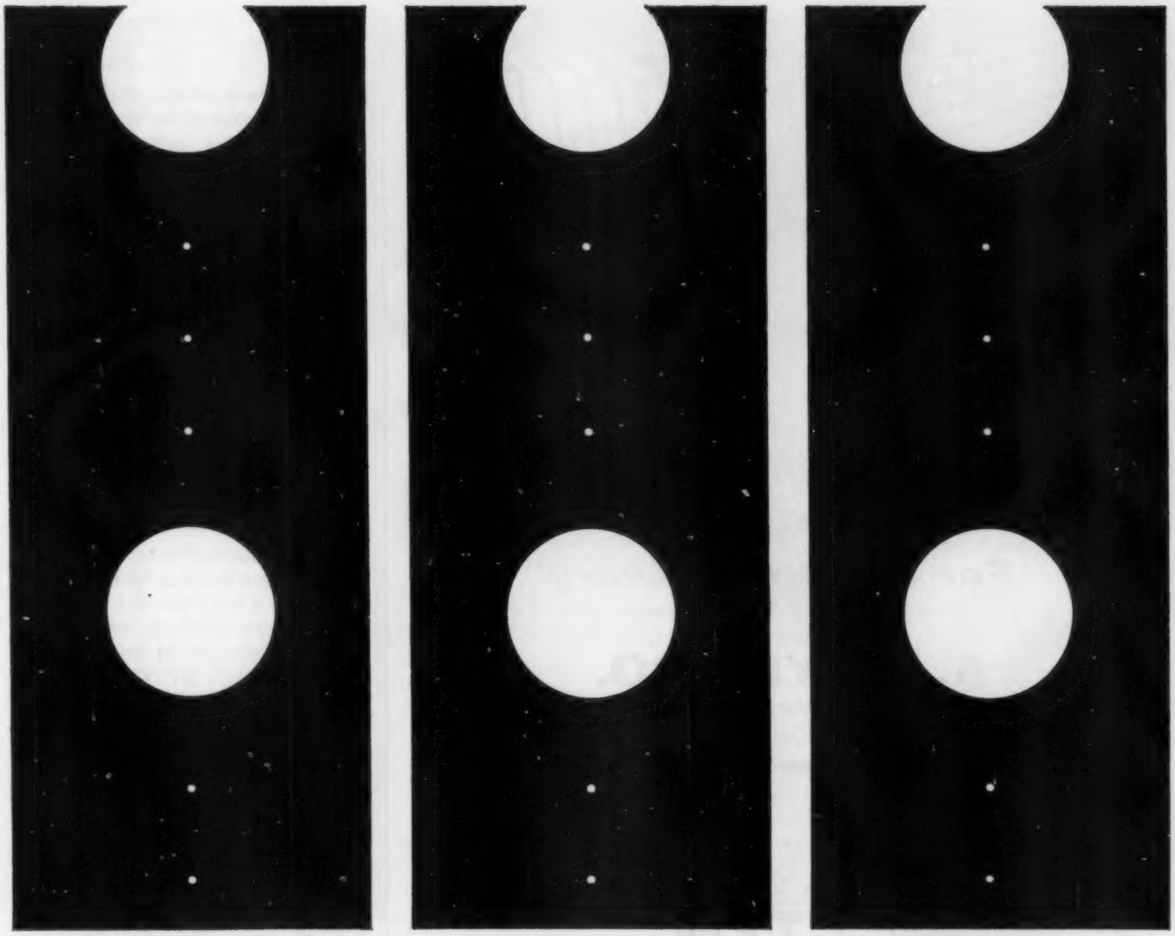
An interesting use of polyester film (Mylar) as a surface for acoustical tile takes advantage of the plastic membrane as a sound-deadening device. Reverse-printed in a decorative pattern, the film is tightly stretched over the tile base to attenuate vibrations, provide a tough, long-wearing, and easily cleaned surface.

And a new returnable corrugated kraft fiberboard container with an outer layer of 1-mil (Mylar) polyester film also attests to the growing versatility of film as surfacing. As used by United Air Lines in a hot food container, the unit is reported to have a life expectancy at least five times that of older models!

But it is in the completely new and unusual area of protective and decorative surfaces for *exterior building materials* that the new industrial film technology is reaching its most significant promise. The volume market represented is large, the implications for plastics films important.

Again it is two of the newer films that have spearheaded the invasion. The first is polyester film. Take Goodyear Tire & Rubber Co.'s Videne as an example. Laminated to wood, the film creates a non-yellowing, stain-, and abrasion-resistant product (with the natural grain of the wood visible beneath the transparent surface) that can be used in the paneling and furniture industry. Laminated to metal, the film goes into walls, ceilings, and partitions; reverse-printed with a decorative pattern, it can enhance the appearance of metal in TV and radio cabinets, furniture, office partitions, etc. Now reverse-printed Videne is also being laminated to flakeboard (by Dexon Products Div., Ingelstroem-Oberlin Co., Massillon, Ohio) to provide a low-priced decorative material ready to be cut to proper size. The surfaced flakeboard can be economically processed with uniformly clean edges on conventional high-speed woodworking equipment.

Polyvinyl fluoride film is also aiming for a market as surfacing for natural woods, hardboards, chipboards, and wood fiber boards, and as a pigmented weatherable finish for steel and aluminum strips. Wear characteristics are reported to be excellent. In sandblast and chip tests, values for laminates ranged from 50 to 100% better than common factory finished lacquers. In retention of gloss after exposure to sunlight and wind-borne abrasives, PVF film surfaces showed



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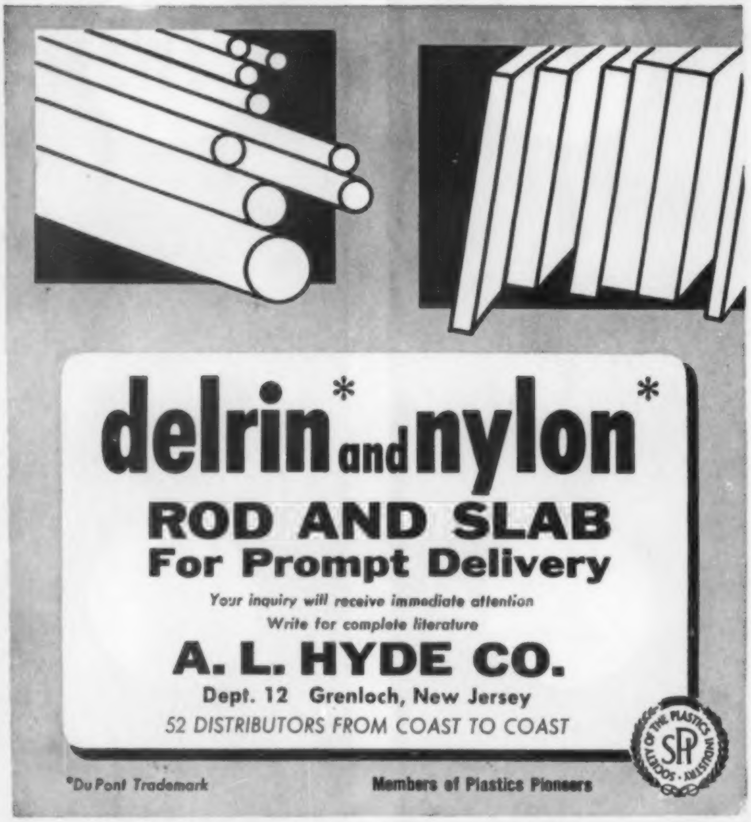

up markedly superior to those based on lacquers and enamels. Cost-wise, it is estimated that once in commercial production, the original cost of factory finishing metal strips with pigmented PVF film will be slightly higher than that for baked enamel and less than anodized aluminum and porcelainized materials.

There are obviously other conventional industrial areas for film use that haven't been mentioned thus far—decorative trim, stationery supplies, conveyors to name just a few—and many that are yet to be developed. Several months ago, for example, John M. Weaver, Bechtel Corp., suggested the use of polyester film as a heat-transfer surface in heat exchangers. For applications of this type, 2-mil polyester film could offer a heat-transfer surface of the same capacity as Monel metal tubing—and at one-eighth the cost! Today, Mr. Weaver reports that his idea has aroused medical interest in the possibility of a disposable plastic film heat exchanger for rapidly lowering and raising body temperatures. This exchanger would be outside the body and would enable operations directly on the heart. And keep your eye on a new oriented nylon developed jointly by Spencer Chemical Co. and Moldings & Extrusions, Inc., Wauregan, Conn. Used in the form of heavy 20- to 60-mil sheeting tough enough to replace—and outwear by 50 to 100%—3-ply fabric core for conveyor belting, the material is being evaluated as film for less critical uses.

With thinking such as this, it is obvious that in the hands of imaginative designers and engineers, plastics films have much to offer. The technology of plastics films as engineering materials is only now starting to build up. It's a radically new concept—but in breaking with conventional materials and techniques of the past, it is providing manufacturers with hitherto unexpected short cuts to better products at lower cost.

For a complete rundown on physical and chemical properties for the films listed in this article, see MODERN PLASTICS *Encyclopedia Issue* for 1961, Films Chart, pp. 626-630.—**End.**

S.P.I. meeting

(From page 104)

suppliers should improve their communications with processors. The present situation, where the end-user knows of new materials before the processor, is not a sound one. Materials suppliers should also review their policies on contract selling, discounts, and laboratory use.

3. The processors themselves should also take certain action to assure their survival. It is suggested, among other things, that:

a. They should specialize more, either by industry served, product range, or process.

b. They should establish for themselves precise selling areas and locate near their markets (one figure suggested was 300 miles).

c. They should keep plant modern, add new technicians, and equipment (an injection machine should be replaced in 10 years).

d. They should cooperate. Joint buying by several molders may achieve discounts. Pooling of press time may be feasible. Even a joint sales force may work in case of processor specialization.

Quality is a must

In outlining the fabulous markets that the plastics industry can penetrate in the '60's, R. C. Weigel, of Du Pont, and president of the S.P.I., stressed in his welcoming speech, the imperative need for good product quality and design if this penetration is to be successful. This exhortation was also taken up by Mr. Cruse in a timely 4-point program that he submitted. His suggestions:

1. Keep quality high to make plastics a trustworthy material.
2. Increase research for more efficient processing.
3. Develop aggressive sales programs to counteract foreign incursions and meet competition from non-plastics materials—which are not going to take the market losses lying down.
4. Cooperation among S.P.I. members for the benefit of the entire plastics industry.

Finally, the consumer representative, Doris R. Menkes of Bamberger's New Jersey, added her voice to the demand for the maintenance of high standards. And what did she want to see being made of plastics? Piano key action, prefabricated garages, roof shingles, transparent sink traps, hub caps, and leaf rakes, to mention only a few.

Presiding at the business sessions were John W. LaBelle, Foster Grant Co., and Richard H. Howe, E. B. Kingman Co.—End

Vinyl in construction

(From pp. 83-86)

The material is continuously extruded by use of a 52-in.-wide sheet die and a newly developed post-extrusion-corrugating form positioned in tandem with the extrusion die. The cost is said to be competitive with other types of corrugated plastic sheeting.

Other vinyl film and sheet applications include: wall tile and covering, with a volume of about 2 million lb. last year; flooring products, which, while not included with most vinyl film and sheet totals, still consume an estimated 157 million lb. a year; and lighting diffusers, now about a 4-million-lb market.

Future developments

Several vinyl developments may some day prove of immense significance to materials producers and processors. An example might be the "all-vinyl" window, currently under development by Pechiney Corp., Paris, France. All sections of the window, with the exception of the glazing panel, will be extruded from rigid vinyl, with extrusion dies engineered by Crane Plastics, Columbus, Ohio.

Six dies for the eight extruded sections have already been approved by Pechiney. Target date for their use is January 1961.

In this country, manufacturers of windows, extruders of window sections, and raw materials suppliers are preparing standards for a window product similar to the Pechiney development.

Ideas of using rigid vinyl chloride for such construction elements as siding, shingles, gutters, and downspouts have been uppermost in the minds of vinyl developers for many years. Hopes have never dimmed that rigid vinyl would someday be a design material for the entire product.

Vinyl siding "in development"

For example, rigid vinyl siding for houses has so intrigued the plastics industry that several million dollars have been spent on experimental development. There are several experimental homes, with extruded, rigid vinyl siding, scattered about in various parts of the country. Results to date have

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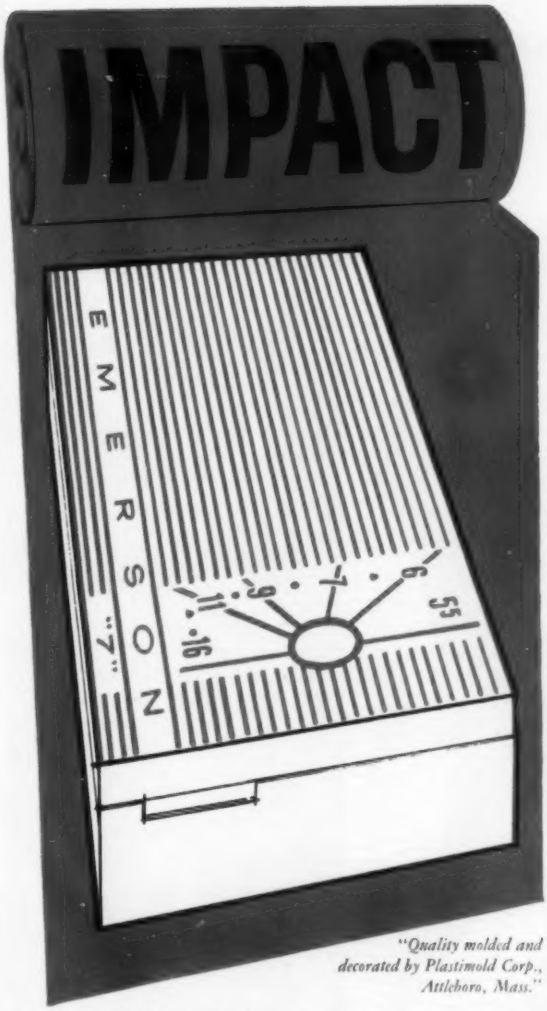

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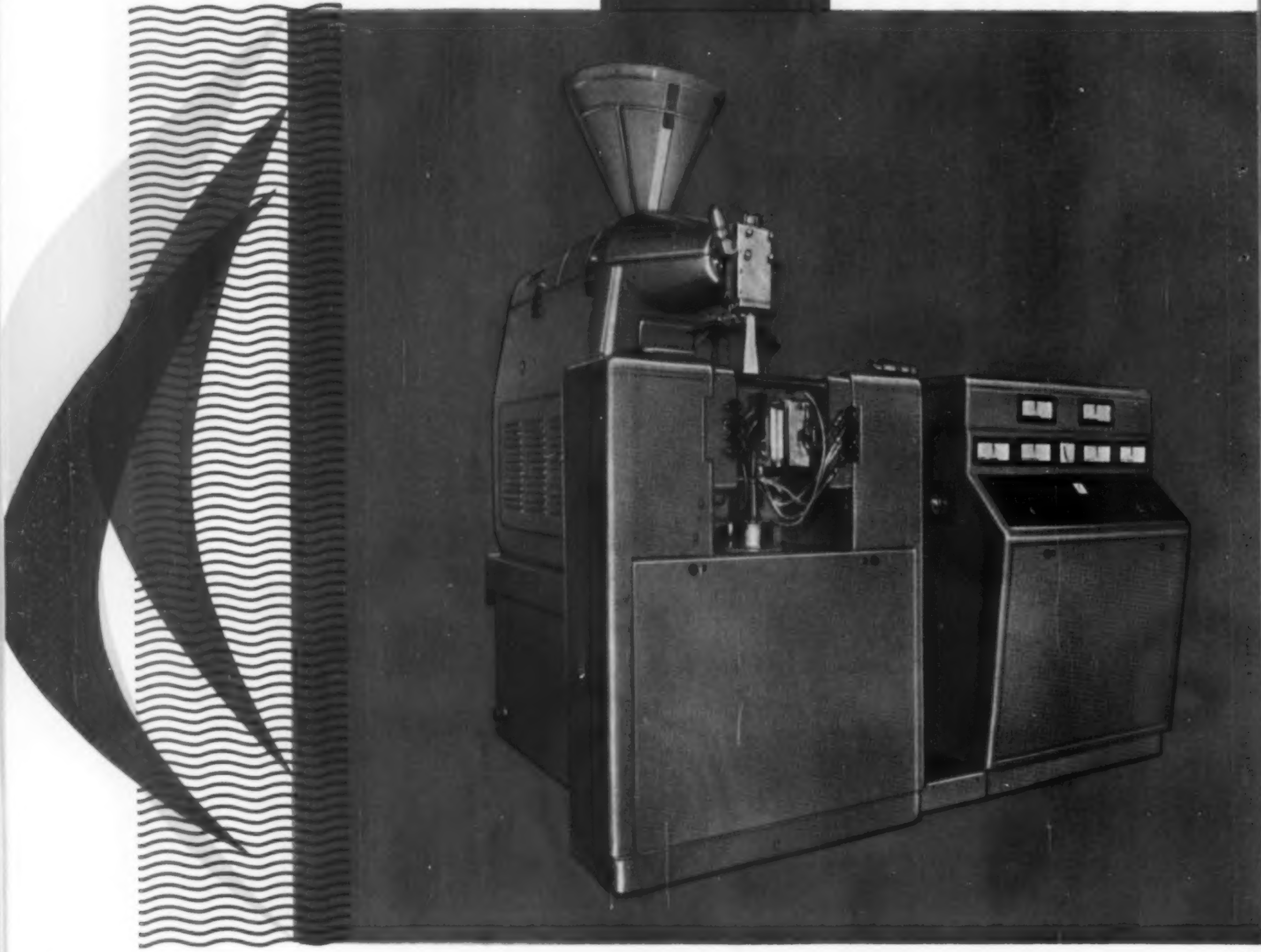

The KAUTEX Blowing Machines fascinated every manufacturer of plastic goods in the world because KAUTEX – biggest blow-moulder in Europe – had put all its practical know-how into its "homemade" machines. It caused a rush of orders which KAUTEX could not swallow. But now comes the news that the KAUTEX Machine Group has grown up to a big plant. If you order a KAUTEX Blowing Automat today, you'll have it soon.

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not yet proved satisfactory—some cracking has appeared and fastening problems have arisen. In much the same way, developments with all-vinyl shingles have reportedly met with problems, particularly in joint forming.

But difficulties with new plastics applications are as old as plastics themselves. Extensive product design and field installation tests must be undertaken before commercial operations can be started. Any worthwhile application has nearly always taken a long time to develop. A rigid vinyl chloride siding will take longer than most others, but although one large producer seems almost ready to give up, there are others who have "just begun to fight."

The versatility of vinyl chloride may suggest to the architect and builder that they do not necessarily have to use the time-tested designs. Perhaps new ideas in design will overcome the problems and bring the desired results with the vinyl products. Vinyl chloride will thus become the builders' tool for introducing entirely new housing concepts to the public.—**End**

Acknowledgments: For supplying information and illustrative material in conjunction with this article, MODERN PLASTICS gratefully acknowledges the cooperation of the following companies: B. F. Goodrich Chemical Co., Cleveland, Ohio; Union Carbide Plastics Co., New York, N. Y.; Goodyear Tire & Rubber Co., Chemical Div., Akron, Ohio; Monsanto Chemical Co., Plastics Div., Springfield, Mass.; United States Steel Corp., Pittsburgh, Pa.; Hastings Aluminum Products Inc., Hastings, Mich.; National Gypsum Co., Buffalo, N. Y.; The Sherwin-Williams Co., Cleveland, Ohio; R. M. Hollingshead Corp., Camden, N. J.; Plas-Chem Corp., St. Louis, Mo.; Solmica Inc., St. Louis, Mo.; New York Wire Cloth Co., York, Pa.; Chicopee Mfg. Corp., Lumite Div., Buford, Ga.; Chemical Products Corp., Providence, R. I.; Lexsuco Inc., Solon, Ohio; Kalikow Construction Corp., Brooklyn, N. Y.; Columbia Broadcasting System Inc., Plastics Dept., New York, N. Y.; National Rubber Machinery Co., Akron, Ohio; and Crane Plastics Inc., Columbus, Ohio.

Shells and bullets

(From pp. 80-82)

new revolver training cartridges are made of molded high-density polyethylene and nylon-6/6.

There is a substantial market for these training cartridges, estimated by some as high as 50 million units per year. This market is composed of the following segments:

Police Departments: Here they are used for both training and for practice. According to one report, one Eastern police department, before the introduction of the plastic shells, kept one man busy full-time reloading metal practice bullets. With the plastic ammunition, this man is now released for more important tasks.

Fast-draw enthusiasts: Their exact number may never be known, but they are organized into an estimated 10,000 clubs. For these fast guns, the plastic bullet is more than an economic relief; it brings much added safety to the sport. Many cases have been reported where, in their haste to get the shot off, such enthusiasts hit a toe, fractured a foot, or wounded a leg. The more cautious ones are now wearing metal armour on leg and foot to prevent such mishap—at significant expense. With the plastic bullets, this problem is overcome.

"Plinkers": These are people who just like to shoot. Such fans can now practice in most any indoor area—their basement, game rooms, back yards—without danger to life and property. This, of course, was not possible with metal bullets.

Summer camps, settlement houses, and the like: Pistol target shooting can now become a safe activity. One type of polyethylene bullet was introduced in Camp Cayuga this summer . . . and results turned out satisfactory to all concerned.

The high-density PE cartridges have been introduced by Colt's Patent Fire Arms Mfg. Co., Inc., Hartford, Conn. Choice of the material, according to Colt, was based on the fact that it provides the necessary rigidity and toughness to allow the cartridge to retain its shape under load shock. Above all, it results in lower costs. For example, in the .45 caliber ammunition, the PE bullets are 5¢ each. The cartridges they replace cost more than twice as much, *e.g.,* 11¢ each (the company makes both .38 and .45 cal. ammunition).

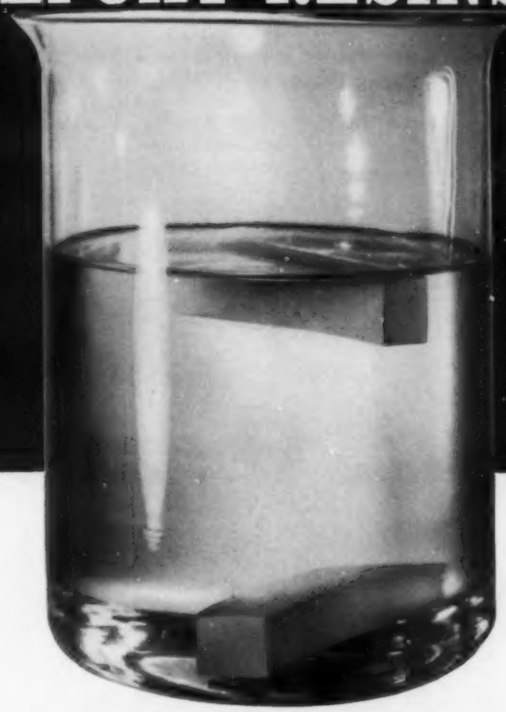
In use, the cartridges are loaded with a wax bullet and powered by a primer only. According to Colt, professional lawmen have tested the bullets and found them reasonably accurate at distances of 15 to 20 feet.

The cartridge casings are molded by Saxe Bros. Inc., Albany, N. Y., of Dow Q917.7 material, with a density of 0.957 and a melt index of 3.5. They are produced on a Fellows 6/10 and an Impco 4-oz. injection molding machine in 24-cavity molds.

Bullets of nylon, also

Another approach to the same problem is taken by Plastics Training Devices, Bloomfield, N.J.,

NEW OXIRONS WEIGH LESS, GO FURTHER THAN CONVENTIONAL EPOXY RESINS



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DIEPOXIDES: Dicyclopentadiene Dioxide, Limonene Dioxide.

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(From pp. 80-82)

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25-Ton Dake laboratory press used to mold experimental resins in a Grand Rapids, Michigan, varnish company.

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which is now marketing a .38 caliber training bullet whose body is molded of Du Pont's Zytel 101 nylon and whose projectile consists of a molded low-density polyethylene head. Cost data are not as readily available as for Colt's bullet, but they are implicit in these comparisons:

1. The previously used metal casings begin to crack after a relatively small number of firings (both metal and plastics cartridge casings are reusable). The nylon casings, on the other hand, have withstood hundreds of firings without ill effect.

2. In order to re-use the metal bullet, a laborious reassembly procedure is required, involving complicated tools and jigs to reshape the lead projectile, to realign the open cartridge end, and to extract the old primer and insert the new. In addition to this step, a new powder charge has to be put into the cartridge.

With the plastic bullet, all the equipment that is required is a conventional awl, which is used to push the old primer out and the new one in. There is no powder charge; the polyethylene projectile is light enough to hit a target with reasonable accuracy at 40 ft. propelled only by the force of the primer explosion.

The bullets are molded by Arnold Molded Plastics Corp., Clifton, N. J., in a single-cavity mold running on a 2-oz. Moslo automatic. The same mold is used for both the projectile and the shell case, and molding is on a 20-sec. cycle. High-density polyethylene was considered for the projectile; but, since both parts are molded in the same mold, shrinkage of the linear PE head did not result in a proper fit with the shell case and low-density polyethylene was specified. In assembling the bullet, the projectile is simply snapped into the cartridge opening and is held in place until fired by a slight projection on its stem which provides a friction fit.

The height of the complete bullet is 1½ in.; outside diameter of the cartridge casing is ⅜ in. and I.D. is ¼ inch. To make sure that the primer fits exactly into the bottom of the cartridge casing, tolerances of the hole are kept to 0.0005 mil, a precision which single-cavity molding makes possible. Plans are under consideration to go to multi-cavity molding (there is enough room on the single-cavity mold base to cut at least seven more cavities), at which time the matter of tolerance will have to be investigated again.

That favorable markets and economies exist for plastics training bullets is strongly underscored by the fact that the military in Europe has been successfully using injection molded PE shells for machine guns, rifles, and anti-aircraft guns. The blank cartridges are produced by first injection molding the specific size needed, putting on a metal end, and then filling with powder. Bakelit Fabriken is said to hold basic rights for the process.

From all evidence, it is apparent that a new market is opening for plastics. If past history is any criterion, the market may soon become one of substantial proportions.—**End**

GATT

(From page 98)

U. S. is currently considering cutting tariffs on many synthetic resins and quite a group of petrochemicals.

Countless plastics products affected

And here we have the problem of the "basket." In May, the U. S. Tariff Commission released a list of products to be considered for possible further tariff concessions at the GATT hearings. A study of this list shows that it is virtually impossible to show all the plastic products and items that might be affected by the proposed tariff cuts. Many of the paragraphs classified by "similitude" in which, for example, some styrene and acrylic products would be listed with cellulosic materials and products, and in which plastics items would be included with manufactures of certain rubbers.

For many years the U. S. has been lowering tariffs, largely on the basis of our vaunted technological and manufacturing superiority in mass production through automation. The trend is *not* about to be reversed, particularly in the case of plastics, which have become quite literally international materials. But there are more tools for protection than tariffs. There are import quotas and the "escape clause" used by presidential decree. There are anti-dumping regulations involving unfair pricing and injury to an American industry.

Tariffs of interest to all

All these factors will affect the decisions made at the GATT meeting. For readers who wish to have their individual say in the matter, there are two committees to be contacted. One is the U. S. Tariff Commission, which is concerned with tariff concessions which other countries are asking of us through GATT. The other is the Committee for Reciprocity Information, which is concerned with the concessions in tariffs and trade which we are asking of other countries. Both offices are located in the Tariff Commission Building, 8th & E Sts., N. W., Washington 25, D. C.—**End**

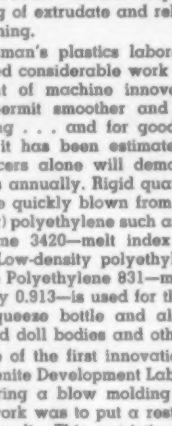
TENITE DEVELOPMENT LABORATORY DOINGS AND FINDINGS

THE CHALLENGE THAT IS BLOW MOLDING

Compared with other engineering achievements, blow-molded polyethylene bottles were launched commercially at a relatively high level of sophistication. Tin cans, for example, were first made by skilled plumbers, who cut sheet metal with shears and soldered it together at the rate of 6 cans an hour. By contrast, blow molding evolved simply as a combination of two older processes: pipe extrusion and thermoforming. This combination immediately eliminated cooling of extrudate and reheating prior to forming.

Eastman's plastics laboratories have devoted considerable work to the development of machine innovations which will permit smoother and faster blow molding . . . and for good reason! By 1965, it has been estimated, detergent producers alone will demand 2 billion bottles annually. Rigid quart-size bottles can be quickly blown from high-density (linear) polyethylene such as Tenite Polyethylene 3420—melt index 0.8, density 0.95. Low-density polyethylene such as Tenite Polyethylene 831—melt index 1.1, density 0.913—is used for the ever-popular squeeze bottle and also for blow-molded doll bodies and other toys.

One of the first innovations made by our Tenite Development Laboratory upon acquiring a blow molding machine for test work was to put a restriction in the parison die. This restriction was created by building up the mandrel as shown by the shaded area of the sketch below. Long experience with pipe extrusion strongly indicated that forcing the molten polyethylene through the restriction would serve to destroy premature orientation and thereby help eliminate nonuniform parisons and weld lines. Subsequent tests have verified this idea.



But better and higher production has not been the only challenge to face resin producer and blow molder. There has also been the need for resins exhibiting special properties and characteristics. In squeeze-bottle applications, for example, Tenite Polyethylene enjoys special popularity because of its superior "snap back." Also much in demand have been resins which produce the very glossy surfaces generally favored for containers. No sooner are these available than—you've guessed it—comes a cry from fabricators for a polyethylene that will give a dull finish, for products such as doll bodies. Work on problems like these can consume almost as much manpower as developing resins with greater resistance to stress cracking.

And speaking of stress cracking . . . wouldn't life be sweet if only oils and greases did not promote stress cracking in polyethylene? We wonder sometimes whether Nellie Bly encountered any such difficulties when she invented and patented the steel oil barrel in 1900.

No need, however, for resorting to a steel drum or even a tin can or glass bottle just to package oil or grease. Containers blow molded of Tenite Butyrate, a cellulosic plastic, not only offer superior resistance to these compounds but also exhibit sparkling clarity and great toughness.

Now, about Nellie Bly . . . yes, she was the newspaper woman who in 1889 went around the world in less than 80 days (72 days, 6 hours, 11 minutes). Admittedly, we don't have any Nellie Blys. But we do have research engineers, development engineers, service engineers and technical representatives who know a good deal about plastic processing. They resemble Nellie only in the amount of travel they do, keeping on top of the latest problems encountered by plastic processors.

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TENITE®

plastics by Eastman

macroPlastic

(From pp. 101-102)

Italy drew considerable attention. Models shown included V55, V111, V175, and V308. Incidentally, the company has diversified its operation and is now also making hydraulic presses, one of which—the Potwell 100-ton—was shown.

22. A 28-oz. injection molding machine (Model 350-P-28) produced in England by Craven Ltd., Sheffield, under license from Hydraulic Press Mfg. Co., was shown with a diagonal plunger preplasticator. The unit has a rated capacity of 135 lb./hr.

23. Plunger and screw-type preplastication—both on one machine and both working independently of each other—were incorporated in the Rotomat 1400/550 series, with a maximum injection pressure of 20,000 p.s.i. The machine is produced by Netstal A.G., Netstal, Switzerland. This is essentially the same machine shown at Kunststoffe 1959. A new model shown in Amsterdam was the Model 260/500, with a maximum capacity of about 16 cu. in. and an injection pressure of 7000 p.s.i. This unit is built along the same lines as the 1400/550 model, except that injection speed has been increased to 1500 cu. cm./sec.

24. Several injection machines were shown by Peco Machinery Ltd., London, England, including the 30/MS 30 MK II (127 to 240 grams), 12 MS 12 (30 grams) and 60 MP 60 (2500 grams, 5½ lb.). The 30/MS 30 is a rapid-operation machine especially suited for thin-wall packaging.

25. A horizontal injection machine, model PR 64-426, featuring a plunger preplasticator with a shot capacity of 2500 g. (88 oz.) was exhibited by Luigi Pomini, Italy, a licensee of Watson-Stillman Co., Ansonia, Conn.

26. Among extruders was one shown by Bandera, Busto Arsizio, Italy, with the relatively small L/D ratio of about 4 to 1 (6.73 in. long by 1.47 in. diameter).

27. A new blow molding machine shown by Kautex-Werk, Hangelar, Germany, incorporates a new extruder with a L/D ratio of 18:1, and a plasticating capacity of about 88 lb./hr., continuously adjustable between 19.8 and 88 pounds. Cycle time is 30 min., including cooling.

28. A small hand-operated welding unit was shown by Hotschmidt G.m.b.H., Augsburg, Germany. Designated Minitherm, the advantage of the unit is the fact that it can produce curved seams without difficulty. The actual sealing is accomplished by a small heated wheel.

29. Rover 175 and 350 (numbers

refer to clamp pressures in tons) series of injection presses from Bühler Bros., Uzwil, Switz., feature interchangeable screw cylinders. Specifications were published in MPl, Sept. 1960, p. 50.

Applications

The housewares, toys, and plastics gadgets shown at macroPlastic were about as good as American products. Likewise, in appliances little new was shown—with one spectacular exception: a rigid vinyl housing for a food mixer molded on Bühler Bros. equipment. Mold design is unusual and Modern Plastics will present this story soon.

It was in industrial and construction parts that new applications showed up. Examples:

A. Transparent rigid vinyl sheets and tanks with steel hardware cloth-laminated inside for strength, by A. H. K. Van Vloten, Bilthoven, The Netherlands.

B. Corrugated translucent vinyl panels by Selchim S. A., Brussels, Belgium.

C. Plastics conveyor rollers in nylon 11 and vinyl by Handelscompagnie N.V., Rotterdam, Holland, and by A. van den Pol, N.V., Nijkerk, Holland, opening a big new market for plastics in conveyors in corrosive atmospheres.

D. Reinforced plastics and filled nylon chains for nautical use by Adr. Beers, N.V., Rijswijk, Holland.

E. Big polyethylene containers with steel mesh molded into bottoms or sides by Vaessen-Schoemaker Handelmij, N.V., Deventer, Holland, giving extra strength to large, fairly thin areas.

F. Epoxy-glass pipes and fittings in large sizes by Bristol Aeroplane Plastics Ltd., Bristol, England, with assured strength-retention at up to 140° C., made, by the way, to American size and pressure specification.

An interesting sidelight on plastics in construction is that Kalwall panels and Tropicel panels, first publicized by Modern Plastics, are now made under license in Europe.

Preceding the macroPlastic show, on October 17, 18, 19 in Amsterdam, Holland, was held a convention of plastics technologists and engineers, sponsored jointly by the Association for the Advancement of the Knowledge of Materials, the Royal Netherlands Engineering Institute, and the Royal Netherlands Chemical Assn.

Full text of all lectures will be published by 't Raedthuys, N.V., Tesselschadestraat 5, Amsterdam, Holland, at $6.75 per copy.

Modern Plastics published the program in the macroPlastic Section of the August 1960 issue.—End

RP conference

(From pp. 128-132)

Vice Chairman: John F. Reeves.

"The Challenge to Marine Design in Fiberglas-RP," E. Pearson, Pearson Corp., and R. White, Celanese.

"RP in the Transit Industry," Hyman Feldman, N.Y.C. Transit.

"Design of Project Mercury Astronaut Couch," Marvin S. Hochberg, McDonnell Aircraft.

Session II—Properties

Presiding: K. Telford Marshall, Whirlpool Corp.

Vice Chairman: James N. Grove, J. P. Stevens & Co. Inc.

"New Qualitative and Quantitative Analytical Methods for Coupling Agents on Glass Cloth," H. B. Bradley, S. Sterman, and B. A. Bierl, Union Carbide.

"Physical Measurements of Reinforcing Roving Properties," D. M. Barnes, Owens-Corning.

"The Effects of Temperature and Humidity on the Dielectric Properties of Plastics," Ralph C. Pratt and Gim P. Fong, Raytheon.

"Physical Properties of 'Mechanically Deposited' F. R. P. Laminate," R. Burkel, J. Bogner, and R. Goold, Chemical Process.

"Properties of Thermally Degraded Ablative Plastics," S. A. Marolo, D. F. Starks, D. L. Schmidt, and H. S. Schwartz, Wright-Patterson Air Force.

Session III—Research, 2

Presiding: H. R. Nara, C.I.T.

Vice Chairman: Frederick J. McGarry, MIT.

"Photoelastic Investigation of Residual Stresses in Glass-Plastic Composites," I. M. Daniel and A. J. Durelli, Armour Research.

"The Stress Distribution in the Resin of RP," D. C. West and John O. Outwater, U. of Vt.

"The Role of Oxidation on the Properties of Polyester Reinforced Laminates," G. H. Hicks, Reichhold Chemicals Inc.

"Some Factors Which Determine Glass-Reinforced Polyester Laminate Quality," R. H. Crederwood, Westinghouse Electric Corp.

"Effect of Impurities on PE Adhesion," J. Bikerman, MIT.—End

ISO Committee

(From page 156)

on Standard Lab Atmospheres and Conditioning Procedures is considering a draft method covering the maintenance of constant relative humidity by means of aqueous solutions and a proposal concerning conditioning of plastics prior to their testing.

Working Group 4 on Thermal Properties has task groups developing standards for the determination of apparent modulus of rigidity in torsion, melt index of polypropylene, flow of thermoplastics and thermosetting materials, as well as for brittleness temperature, and Vicat softening point of thermosets.

Working Group 5 on Physical-Chemical Properties has work under way on the determination of chlorine in vinyl chloride polymers and copolymers, vinyl acetate in vinyl chloride/acetate copolymers, dilute solution viscosity of polyolefins and acrylic polymers, and refractive index.

Working Group 6 on Aging, Chemical, and Environmental Resistance withdrew the First Draft Proposal on resistance of plastics to change of color in artificial light using the carbon arc, which was directed specifically to the testing of polystyrene, in favor of drafting a proposal dealing broadly with exposure of plastics to carbon arc light. Task groups are also developing proposed standards for determination of resistance of plastics to mould, loss of plasticizer in ventilated ovens, stress cracking of polyethylene, and thermal stability of polyvinyl chloride.

Working Group 7 on Preparation of Test Specimens organized a task group to prepare a standard describing a mold for specimens of thermosetting materials and the cutting of specimens from molded sheet.

Working Group 8 on Electrical Properties considered various documents relating to dielectric strength, insulation resistance, tracking, dielectric constant, dissipation factor, and electrolytic corrosion, and prepared recommendations concerning these properties for submission to IEC/TC 15, which meets in New Delhi, India, in November.

Working Group 9 on Specifications initiated the development of a specification for phenolic molding materials to cover grades for the following types of application: 1) general purpose, 2) mechanical, 3) heat resistant, 4) electrical, and 5) chemical. Other materials scheduled for early consideration are industrial phenolic laminates, rigid PVC, and polyethylene.

Tenth group organized

A resolution to organize a new **Working Group on Cellular Materials** was approved at the second plenary session of ISO/TC 61. The work of this new group will be coordinated with that of Working Group H on Flexible Cellular Materials of ISO/TC 45 on Rubber under the aegis of a Joint Coordinating Body.

The 1961 meeting of ISO/TC 61 will be held in Turin, Italy, Oct. 2-7, and the 1962 meeting in Warsaw, Poland.—**End**

Electro-erosion

(From pp. 109-114)

advantages of the process explained in the text often result in economic advantages as well. In some cases it is possible to save as much as 75% in the time and effort required to make a given mold by the more conventional methods.

Molds shown in Fig. 9, p. 114, along with the electrodes used to cut the cavities and parts made in the molds, are good examples of the savings possible. When one considers the amount of sectioning and hand labor that would have been required to finish these molds using conventional cutting tools, and then considers that these molds were cut to tolerances of + or −0.0002 in. and a finish of 10 to 15 μin. directly into a hardened steel block, the time-saving advantage of electro-erosion is apparent. Figure 10, p. 114, shows another plastic part and the two copper electrodes used to cut the finished cavity which produced it.

It is obvious from the illustrations presented that, in the case of very complex molds, many electrodes are often necessary to produce the many cavity configuration combinations required to complete the mold. These, of course, represent an investment in terms of the man-hours required to machine the electrodes themselves. For this reason, it should be apparent to the reader that electro-erosion is not always the cheapest or best way to make all molds. Each molding machining problem will have to be carefully analyzed to determine whether conventional machining techniques or electro-erosion methods are the optimum answer in each case.

In general, for simple cavities of regular shape and which will obviously require little hand work, conventional cutting machines which actually cut metal at much faster rates are probably the best answer. For example, a simple cylindrical cavity, which can either be turned on a lathe or easily cut in a drill press, will probably be cheaper to produce by the conventional cutting equipment. On the other hand, if one

wanted to produce a square, sharp-cornered, gear shape, narrow slot or a sharp-pointed star pattern cavity, it would probably be cheaper and faster to use electro-erosion.

In many cases the best answer will be a combination of the two methods, using conventional cutting machines for rough shaping and using electro-erosion for fine finishing.

Another cost consideration is the initial cost of the equipment. Electro-erosion machines represent an investment of between \$15,000 and \$25,000 or more each, depending on the accessories and special features desired. This compares to an average of anywhere from \$1,000 to \$10,000 for conventional cutting equipment of various types and sizes. However, although the initial investment is greater, the savings which can be realized in terms of lower production cost often offset the initial expense of the machine, especially when complex mold work is called for.

Another saving arises from the use of electro-erosion in that it is a machine that a man can learn to operate in a short time and the investment in operator training is considerably reduced. This is becoming increasingly important in view of the current shortage of skilled toolmakers resulting from the demand outstripping the supply. Since it takes many years to create a good toolmaker, relief of this situation is not visible in the near future.

Summary

Based on the discussion above, electro-erosion represents a major advance in the technology of building plastics molds. Because of the high precision and high quality of the complex molds which can be made using electrical discharge machines, it is a process which is expected to find widespread use in the plastics industry. In addition to quality and precision, its ability to cut cavities which were either too costly or impossible to cut by conventional methods also promises to open up new applications for plastic molded parts. The technique will require some changes in mold builder's production routines and methods resulting from the use of a new cutting tool, the electro-erosion electrode. The use of the electrodes will require the mold maker to visualize cavity-cutting jobs in terms of the number and types of electrodes which will be required. However, this should be an easy task for the mold engineers who are accustomed to working in terms of complex spatial relations.

It is doubtful if electro-erosion will obsolete in any way the use of conventional metal-cutting tools. In fact, conventional metal-cutting machines will still outperform the electro-erosion machine on most of the simpler cavity-cutting problems. Rather, the addition of the electrical discharge cutting machine to the mold maker's tool box will make possible the more efficient use of conventional cutting equipment and, in some cases, it will speed up the over-all mold-making process.—**End**

Behavior—Part II

(From pp. 147-154)

analysis presented, it appears that the desirable properties and characteristics of ablative plastics are:

1. The organic resinous material should degrade into large volumes of gaseous products. These pyrolytic vapors should be of low molecular weight, high heat capacity, and high diffusion coefficient.

2. For carbonizing resins, a strong and porous surface char should be formed with the amount of char depending upon the nature of the heating environment. This carbonaceous residue should serve to insulate thermally the remaining substrate plastic. It should be capable of reaching a high temperature and be of high emittance for appreciable radiant emission.

3. The inorganic reinforcements of a plastic composite should mechanically reinforce the intact and residual char materials, and prevent thermal shock failure. These reinforcements should also possess a high specific heat, high melting temperature, high melt viscosity, high surface tension, and vaporization temperature close to the melting temperature, as well as large endothermic heats of phase changes.

4. The initial ablative plastic and its residual products should have a low thermal diffusivity to minimize heat penetration into the substrate material.

5. Surface removal during interaction of the material with its environment should be uniform and should result in a smooth ablating surface.

Plastics absorb and dissipate heat during re-entry by the combined action of the following mechanisms: internal heat conduction and storage in the solid body, convection in the liquid layer if one exists, mass transfer in the boundary layer, phase transitions, radiant energy transport, and chemical reactions. The amount of energy expended by each process depends upon the materials' properties and the nature of the heating environment.

Additional materials research is required to provide a thorough understanding of the behavior of various plastics in very high temperature environment, and to improve existing materials. Studies on the thermokinetics of plastics degradation and on the homogeneous and heterogeneous reactions of ablating plastics are expected to contribute greatly to our future knowledge.

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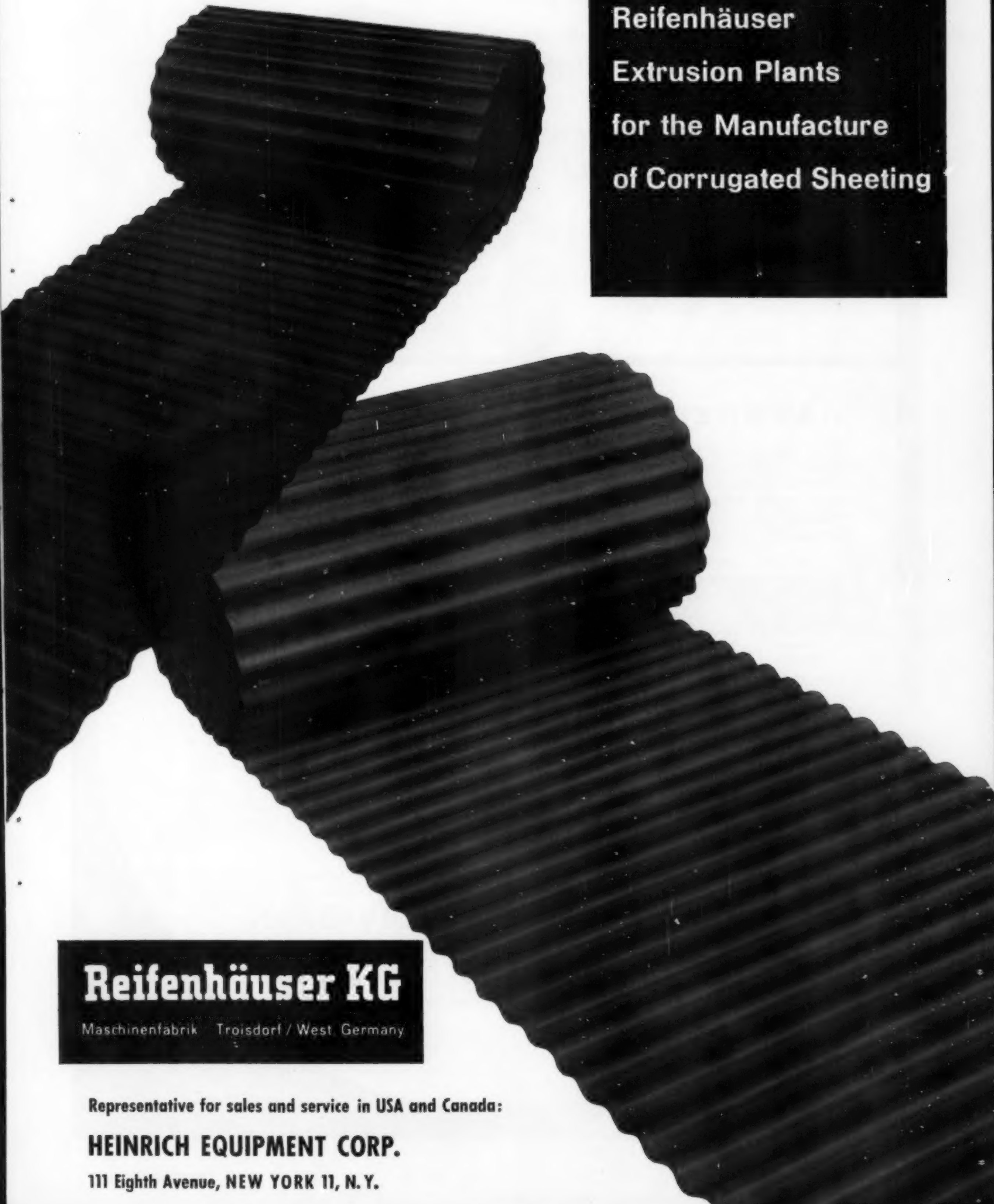

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Mold flow

(From pp. 117-120)

the time measured from the instant the flow entered the cavity. The abscissa in Fig. 3 is the time measured from the instant the pressure was applied to the system. The experimental conditions for curves in Fig. 3 are shown in Table III, p. 119.

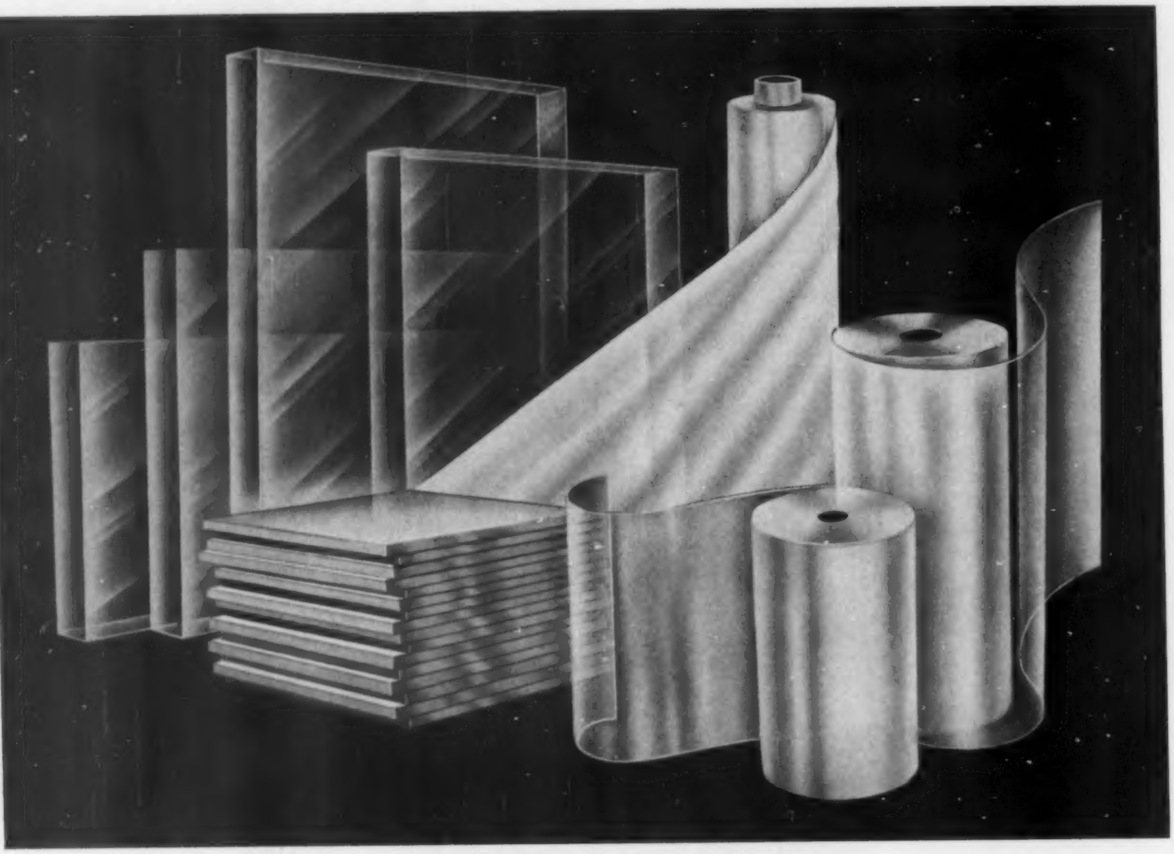
Equation 19 is equivalent to the linear relationship between V and X that are shown in Figs. 4 and 5, p. 120, where this same data are plotted.

It is seen in Fig. 3 that the isothermal distance-time curves diverge increasingly from the measured value as time increases. These curves were computed from the equation for isothermal flow (3), with the rheological constants evaluated at the entering polymer temperature of 325° F. The isothermal curves give an infinite fill-out.

The non-isothermal computations are seen to give an excellent prediction of the length of flow in both experiments over the range in which these computations were carried out, even though the heat transfer in the channels preceding the cavity was neglected.

A clearer picture of the results is obtained by considering the velocity - distance relationships shown in Figs. 4 and 5. The non-isothermal calculations are seen to do a much better job than any of the isothermal equations since the isothermal equations give an infinite fill-out for any temperature. It is clear from this manner of presentation that the non-isothermal calculations have covered a major part of the flow and it is not difficult to extrapolate and find that the predicted fill-out is 16% high in run 1 and 10% high in run 2. This agreement is considered to be entirely satisfactory considering the approximations that were used.

When similar computations which neglected heat transfer in the channels were carried out with runs in which longer channels were used, the predicted lengths were considerably greater than measured, so the somewhat high predicted fill-out in these short channels could be attributed to the small heat transfer



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Acetate Butyrate	X	X	X	X	X
Polystyrene	X	X	X	X	X
Plexiglas & Acetate with Embedments		X	X		
PVC		X	X	X	X
Polypropylene		X	X		
Polyethylene—Regular	X	X	X	X	X
Polyethylene—High Density		X	X		
Propionate		X	X		
Nylon		X	X		
Delrin		X	X		

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which takes place before the cavity is reached.

However, the differences between the computed and experimental results could also be caused in part by the approximations used inside the cavity. It is obvious, for example, that the slab-like flow assumption which was used to compute the heat transfer in the cavity cannot be correct in its details, for the history of any particle is usually quite different from that which was assumed.

Nevertheless, since part of the discrepancy between computed and experimental fill-out must be due to the heat transfer in the channels, it must be concluded that the gross flow process, as measured by the mean velocity, is adequately described by the present model. Consequently, relatively minor modifications of the present program should allow prediction of the flow in more complicated geometries of the type encountered, for example, in injection molding. And since there is no reason to expect the procedure to be limited to polystyrene, it should be possible to predict the flow of a variety of other materials as well.

Acknowledgment

The authors wish to thank R. I. Dunlap, R. L. Heider, G. W. Ingle, and T. Shusman for their help in carrying out this work. Thanks are also due to J. W. Judd who wrote the 702 program, and L. H. Krone who wrote the 704 program.

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Silane coupling agents

(From pp. 135-142)

bonds between the water molecules. Organic contaminants and dissolved gases are present(7). The fact that much of the water is tenaciously bound is indicated by the fact that it cannot be removed except by long exposure of the glass to high temperature (840 to 930° F.) and high vacuum(7,8). This tightly bound water is probably present as a silica-gel-type structure on the glass surface. It is possible that E-glass employed in fiber glass manufacture behaves differently than ordinary glass because of its high silica content and absence of alkali metals. In a recent communication from the Owens-Corning Fiberglas Corp.(9), it was stated that E-glass, a water-durable type, does not absorb water as do the more water-sensitive types employed by DeBye(8) and others. However, some water or silica hydrate is no doubt necessary to hydrolyze the silane chloride or ester, resulting in a Si-O-Si bond to the glass surface.

Laminates were made with glass cloth dried at 840° F. under high vacuum for 4 to 6 hr. to determine whether any improvement in laminate properties could be observed. Laminates were prepared using no silane, silane in the resin, and silane reacted with the glass prior to formulation. Under these conditions the bulk of the water should be removed leaving a "clean" glass surface for reaction with the silane.

Drying glass cloth at this higher temperature immediately produced a darkening due apparently to the degradation of organic matter at the surface. This was easily removed by heating in air at 840° F. for several hours before evacuating.

Data obtained using glass cloth dried at 840° F. are shown in Table VII, p. 142, contrasted with control samples prepared similarly, but with the cloth dried at 212° F. and with no precautions to exclude atmospheric moisture during lay-up. It may be noted that the extreme drying produced some increase in dry flexural strength in all cases, but the improvements are not great. Some

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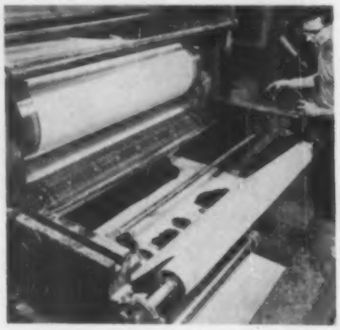

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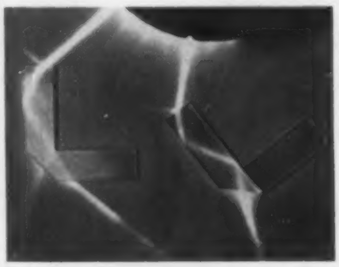

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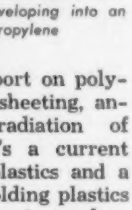

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improvement in wet flexural strength when using the water-free glass is also indicated. Improvement in the clarity of laminates prepared with the dried glass was considerable when the silane was employed.

Discussion

The literature indicates that the vinyl group of the $CH_2=CH-Si\equiv$ structure polymerizes with difficulty(1). This is true whether the vinyl siloxy group exists as an ester or as the condensed siloxane. It should be realized, however, that a siloxane formed from vinyl silicic acid has many vinyl groups in each molecule and copolymerization of only one vinyl group with the resin constitutes a chemical bond.

Although styrene is less reactive towards vinyl siloxanes than are more polar vinyl monomers such as acrylonitrile, vinyl acetate, and vinyl chloride(10), our work with styrene-VTES mixture indicates considerable copolymerization occurs at 225° F. and higher temperatures. In a typical resin-glass system such as that of a polyester-styrene, the mass action effect of the high proportion of styrene as compared to the vinyl silane coupling agent should favor more complete copolymerization of the silane than when an equimolar mixture is used as was the case involving our various experiments.

The polyester itself would appear not to copolymerize with a vinyl silane coupling agent during normal curing conditions. However, once the styrene reacts with the vinyl silane agent, it is then brought into the styrene-polyester matrix.

The polymer resulting from the reaction of resin constituents with the coupling agent may well be of low molecular weight, even liquid in nature. Such a bond would contribute to the strength of the reinforced plastic largely by making possible better "wetting" of the glass by the resin, but should make a major contribution to water resistance. However, when using a more reactive unsaturated silane, such as that containing the styrene nucleus, more complete reaction of the coupling agent with the resin to give higher molecular weight copolymers and tripolymers should result and laminates of higher strength should be formed than when using the vinyl silane. Based on our limited data, this does not appear to be the case. Use of the styryl silane may be advantageous for room temperature cures. However, water resistance of laminates employing the styryl silane coupling agent is actually inferior. This is likely due to incomplete coating of the glass surface by the styryl silane due to hindrance by the large styryl or styryl-ethyl group. Even though strong chemical bonding may exist, the small water molecules are able to penetrate to the unprotected portions of the glass surface.

If the silane is added as an ester in the resin, its solubility should be marginal so that it will migrate to and coat the glass when contacted. This is emphasized in Table V, where better strengths were obtained with the hydrolyzed triethoxysilane than when it was added in a dry resin.

The good results obtained with dimethyl vinyl chlorosilane (Table VI) indicate that a condensed siloxane structure is not necessary in order to get good water resistance. Theoretically, if two molecules of such a silane should condense, it would be impossible for the dimer to react with the glass surface. The attainment of equally good water resistance without siloxane formation when using a monofunctional vinyl silane is a somewhat different picture than is usually presented as to how the silane functions in improving the strength and water resistance of glass laminates. It was observed from the several laminates made from glass cloth containing the vinyl dimethyl silane finish that highly uniform results were obtained when using this finish. This was true for specimens cut from a given laminate as well as specimens from two different laminates prepared under like conditions. Flexural values checked within about 1000 p.s.i. Adhesion of the silane to the glass by single bonding without the possibility of siloxane formation should result in a more uniform finish on the glass surface. This appears to be

the case when using the vinyl dimethyl silane.

Use of divinyl silane finish on the glass has consistently resulted in superior water resistance properties. Additional data on the use of divinyl silane support those cited in Table VI in that loss in flexural strength after immersion in boiling water for 1 wk. is only a few thousand p.s.i. In another example, a laminate was prepared with heat-cleaned 181 glass cloth that had been treated with divinyl dichlorosilane. The resin used was all-hydrocarbon in nature, but somewhat different than that used with the laminates cited in Table VI. Data from the 181-cloth laminate included the following:

Sample	*Flexural strength*
	p.s.i.
Original	59,500
Boiled in water	
2 hr.	61,000
24 hr.	59,000
7 days	56,500

The divinyl silane, as expected, appears capable of copolymerizing at a lower temperature than does the monovinyl. Thus, it should be particularly advantageous for use with the polyesters.

It is theoretically possible that the bond between resin-glass could fail at the coupling agent when it consists of a siloxane structure. Use of vinyl silane on typical glass fibers in 0.5% concentration, calculated as A-172, should provide a layer 10 to 20 molecules thick on the glass surface if evenly distributed. The surface area of glass fiber is taken as 880 sq. ft./lb. and the silane is calculated as the silanol, $CH_2{=}CH{-}Si(OH)_3$. Our experiments with vinyl silane used in concentrations up to a 4-fold difference resulted in no appreciable differences in laminate strength. This would indicate that it is unlikely that fracture of the bond occurs in the siloxane layer itself.

Little thought has apparently been given to the bond between the coupling agent and the glass. When applying the vinyl silane to glass as an aqueous solution, a maximum water film and hydrated silica layer on the glass would result.

Experiments are reported in Table VII in which the glass cloth was rendered substantially water-free by heating at 840° F. under an excellent vacuum and then contacted with vinyl trichlorosilane prior to exposure to the atmosphere. Even under these drastic conditions of heat and vacuum, enough hydroxyl groups remained on the glass surface to react with the silane. Unreacted silane was removed by washing with anhydrous methanol. It is likely that a certain concentration, presently unknown, of hydroxyl groups must exist on the glass surface in order to get maximum effectiveness when treated with a given silane. In any case, much better strength and water resistance were obtained when using a vinyl silane with the "anhydrous glass" as compared to when no silane was used. Although the data are too meager to make firm conclusions, it would appear that the E-glass does have a layer of silica gel on the surface, and as expected, heating at 840° F. is not a high enough temperature to remove all of the chemically bound water.

It is difficult to say what the ultimate strength of a high-glass laminate could be. It should be appreciated that the glass fibers employed as the 181 fabric had no doubt suffered in strength in the weaving and other handling operations and the heat-cleaning to remove sizing. The extra strength realized on removing the water may be near the ultimate.

Use of epoxy resins to prepare glass cloth laminates in the usual manner results, as a whole, in laminates of somewhat greater strength than when using polyester or polybutadiene-type resins. This is believed to be due primarily to two reasons:

1. The epoxy resin reacts with the water film and silanol groups on the glass surface, thus substantially removing this barrier between resin and glass and chemically bonding to the glass.

2. Since epoxy resins condense linearly as well as crosslinking, the resin casting is of relatively high strength.

Conclusions

Although more work is obviously needed to clarify the factors which limit the strength of the

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resin-glass bonds when using a vinyl silane coupling agent with a peroxide-catalyzed resin system, the following conclusions are indicated:

1. Chemical bonding of the vinyl silane to the resin may or may not occur, depending on curing conditions.

2. If good chemical bonding of resin to coupling agent results, the weaker bond may be between the coupling agent and the glass.

3. It would appear that a substantial improvement could be made in glass-reinforced plastics of the polyester and polybutadiene types if glass fiber free of moisture were available for use and if cure conditions were chosen so that a high degree of copolymerization of the coupling agent and the resin results.

Acknowledgment

The authors are indebted to the Union Carbide Corp., Silicones Div., and the Dow Corning Corp. for providing various silane samples. Helpful discussions with various representatives of these companies as well as those with Dr. Robert Ullman, Brooklyn Polytechnical Institute; Dr. E. G. Rochow, Harvard University; and Dr. D. J. C. Yates, Columbia University; are gratefully acknowledged. Support of this work by the various affiliates of the Standard Oil Company (N. J.) is sincerely appreciated.

The literature references given are not complete, and those cited are used primarily to exemplify information in the literature, and should not be construed as the most pertinent.

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THE PLASTISCOPE*

News and interpretations of the news

By R. L. Van Boskirk

Section 2 *(Section 1 starts on p. 41)*

December 1960

Rigid polyether foams

A two-package polyether foaming system for the production of rigid polyurethane foams has been developed by Pittsburgh Plate Glass Co. Designated Selectrofoam 6504 and 6505, the system is designed primarily for refrigeration applications such as household refrigerators, freezers, display cases, cold storage rooms, etc., and is also said to be advantageous for building panel cores, packaging, truck and trailer insulation, and refrigerator rail car insulation.

The density of the Selectrofoam 6504-6505 system is 1.6 lb./cu. ft. for open expansion foaming, or 2.3 lb./cu. ft. for molded foam. Other advantages claimed are low water vapor transmission and good dimensional stability.

Extruded polycarbonate sheets

Rowland Products, Kensington, Conn., announced its first sheet extrusion production run of Mobay's Merlon polycarbonate. In addition to exceptional mechanical strength, superior dimensional stability, and good electrical properties, Merlon is transparent, has low water absorption, is non-staining, self-extinguishing, odorless, and tasteless. Now manufacturers will be able to secure Merlon in 22- by 51-in. sheet sizes in gages of 0.020 to 0.250. Test samples are available from Rowland Products for development studies.

Large size PP sheet

A polypropylene sheet, measuring 4 ft. wide, 8 ft. high, and 2 in. thick, has been developed by the Seiberling Rubber Co., Plastics Division at Newcomerstown, Ohio. Claimed to be the world's largest polypropylene sheet, it is used in this size by fabricators to produce drums for the electro-plating industry. Metal for new automobiles, for example, is passed through the drums for hot baths in either chrome or nickel plating solutions.

The material called Seilon Pro, reportedly withstands temperatures as high as 300° F., and is said to have good resistance to corrosive chemicals.

Giant foam blocks

Molding equipment which produces expanded polystyrene foam, ready for use, in extra-large blocks, is now in operation at General Foam Products, a subsidiary of Stauffer Chemical Co., Vernon, Calif. It delivers finished blocks and boards of Structo-Foam foamed plastic in a range of sizes up to 12 ft. long by 4 ft. wide by 18 in. thick. The material is said to be so light that a block of the size mentioned above weighs less than 80 lb.; it is becoming popular for insulation and flotation applications in marina construction, according to a company spokesman.

Air bubble curtain aids fishing

Polyethylene tubing has come to the aid of commercial fishermen. A compressor on the fishing boat forces air through submerged flexible PE tubing that incorporates numerous holes. As the air escapes underwater and rises to the surface, it forms a curtain of air bubbles which seem to frighten the fish and through which they will not pass. This allows fishermen to actually ride herd on the herring and drive them from deep water and fast currents into the seine nets nearer shore. The new technique was originated by Keith A. Smith, chief of the Maine Herring Exploration and Gear Research, a project of the U. S. Dept. of the Interior.

Polymeric plasticizer

A liquid vinyl plasticizer, said to give unusually fast fusion rates in vinyl formulations, has been developed by Hatco Chemical Div., W. R. Grace & Co. Designated Hatcol 640, the new product has excellent permanence, good compatibility, and exceptionally low volatility, according to the company. It is recommended for use in the manufacture of automotive film and sheeting, refrigerator gaskets, electrical tape, and fabric coatings, and is competitively priced at 38½¢/lb. delivered in 2000-gal. lots.

New electrical conduits

Two new lines of rigid plastic electrical conduits have been developed by Wheatland Electric Products Co., Carnegie, Pa.

Rigid polyvinyl chloride conduit is available in two types; Type A-Light Wall and Type 40-Heavy Wall. These are designed for installations both above- and underground, are gray in color, and produced in sizes ranging from ½ in. through 6 in., and 10-ft. to 20-ft. lengths.

The Wheatland line of underground plastic conduits known as Type I-Light Wall and Type II-Heavy Wall are manufactured from specially compounded, modified styrene. Type I-Light Wall, designed for concrete encasement, is produced in 2-in. through 6-in. sizes. Type II-Heavy Wall, for direct earth burial, is produced in 1-in. through 4-in. sizes. Both types, black in color with an identifying yellow stripe, are available in 10-, 20-, and 30-ft. lengths.

Cyanocel

A new material claimed to have the highest dielectric constant of all known organic film-forming materials has been developed by American Cyanamid Co. Known as Cyanocel chemically modified cellulose, this material also has a low dissipation factor. With this combination of electrical properties, Cyanamid's new product is

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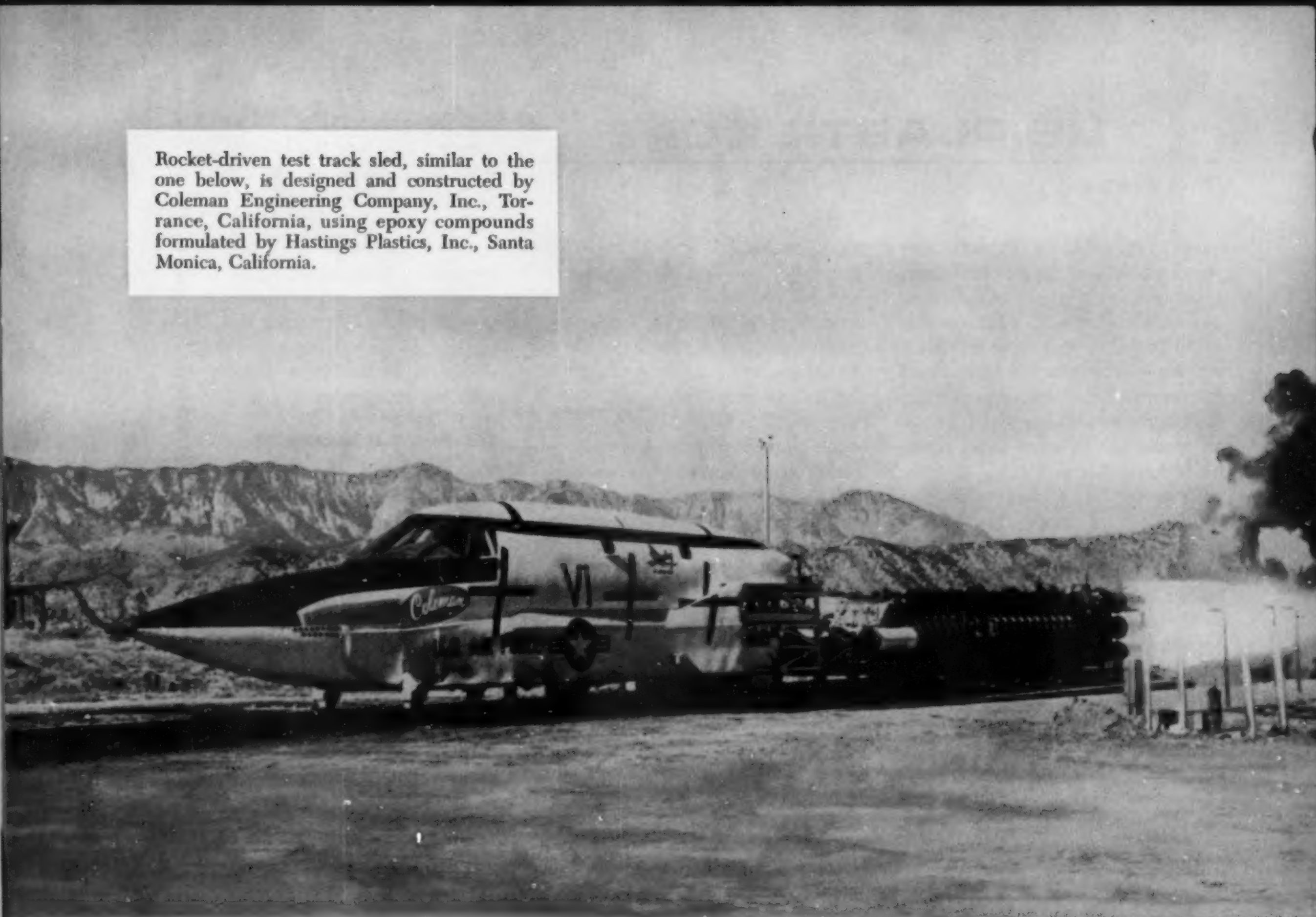

Rocket-driven test track sled, similar to the one below, is designed and constructed by Coleman Engineering Company, Inc., Torrance, California, using epoxy compounds formulated by Hastings Plastics, Inc., Santa Monica, California.

Epoxies Pass the Test

AT SUPERSONIC SPEEDS

Rocket propelled, test sleds at the Hurricane Supersonic Research Site travel faster than Mach I, providing performance data on components for future supersonic vehicles. To meet such working conditions and keep cost, weight, and tooling at a minimum, these vehicles and nose cones are constructed of glass cloth laminated with epoxy compounds based on BAKELITE Brand epoxy resins.

Epoxies offer multiple advantages to fabricators of reinforced plastics. Epoxy-glass cloth laminates have excellent fatigue resistance, very high strength-to-weight ratios, and a very low coefficient of expansion. The extremely versatile nature of BAKELITE epoxy resins leads to their widespread use in coatings, adhesives, and casting and potting materials.

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(From page 218)

said to provide a capacitance-per-unit volume two to six times greater than that of other comparable products. Two known applications for the new material are electroluminescent lamps and microminiature capacitors. Its first commercial use will be in an electroluminescent lamp made by General Electric Co.

Cyanocel is a white, fibrous solid that is made by adding acrylonitrile to a highly refined form of cellulose. The process is known as cyanoethylation. Films as thin as 0.1 mil and as thick as 5 mils or more have been cast from solutions of Cyanocel in various organic solvents. American Cyanamid has set an initial price of $27/lb. on its developmental product.

Fibrous glass skylight for pier

Twenty-two thousand sq. ft. of translucent fibrous glass panels have been installed as skylighting for Pier 1 in Brooklyn as part of the New York Port Authority's recently completed $85-million waterfront redevelopment program. The corrugated fibrous glass panels, which mate with aluminum roof sheeting, were supplied by Barclite Corp. of America, New York, N. Y.

New grade vulcanized fiber

A new electrical grade of flame-resistant vulcanized fiber with improved dielectric strength and arc resistance has been announced by National Vulcanized Fibre Co. The new material, called Pyronil E, is intended for use as a combination flame, heat, and dielectric barrier in electrical and electronic equipment.

Gray in color, Pyronil E is available in rolls, coils, or sheets in thicknesses of 0.010-in. to 1/16-inch.

Package foaming system

A rigid urethane foaming system based on two components, Aropol 7825 and Aropol 7846, that can be combined on a simple 1:1 ratio has been developed by Archer-Daniels-Midland Co. The packaged system is a Freon-blown polyether formulation that can be sprayed or hand poured, and is said to be suitable for insulating, void filling, and similar applications. A pint or a pound of Aropol 7825, combined with the same amount of Aropol 7846, will produce approximately 1 cu. ft. of foam, according to the company.

The ADM foaming system is also available in formulations that will produce foams up to 35 lb./cu.-ft. density.

Lexan prices reduced

Price reductions of up to 25¢/lb. for Lexan polycarbonate resins have been announced by General Electric Co.'s Chemical Materials Dept. The new price schedule for standard grades ranges from $1.30 to $1.75/lb., or up to 41% less than prices prevailing six months ago. Mobay Chemical Co. will undoubtedly follow suit for its line of Merlon polycarbonates.

Bachner Award judges named

A four-man panel has been named to judge entries in the 2nd Bachner Award Competition for outstanding achievement in plastics.

Appointed were: *William P. Gobille*, Manager, Plastics Operation, American Motors, Detroit, Mich.; *Ivar P. Jepson*, Vice President, R & D, Sunbeam Corp., Chicago, Ill.; *Dr. Ralph G. Owens*, Illinois Institute of Tech., Chicago, Ill., and *Hiram McCann*, Editor-in-Chief, MODERN PLASTICS.

For details on the Bachner Awards Competition, its entry rules, and prizes, see MODERN PLASTICS, Nov. 1960, p. 240.

Itaconate monomers

The carload price on Itaconic Acid-Technical is now 34½¢/lb.; Acid-Refined is now 49½¢; and carload prices on Dimethyl Itaconate and Dibutyl Itaconate are now 39½¢, a 27% drop. The above new price schedule was announced by the producer, Chas. Pfizer & Co. Inc.

Polymer chemists are said to have obtained new results with Itaconic Acid because of its unique molecular structure. As an example, there are the Italian thermoplastic molding compounds, Dialux A and Dialux C, which are high styrene copolymers of Dimethyl Itaconate with physical properties resembling polymethyl methacrylate. There are also polymeric coatings that use Itaconic Acid as a comonomer to improve adhesion to a variety of selected substrates.

PE film for packaging

Three-mil, seamless polyethylene bags, designed and produced by The Dobeckmun Co., Div. of The Dow Chemical Co., are being used in some markets by American Crystal Sugar Co., Denver, Colo., for packaging 5-lb. units of granulated sugar. The packages are flexographically printed in three different colors.

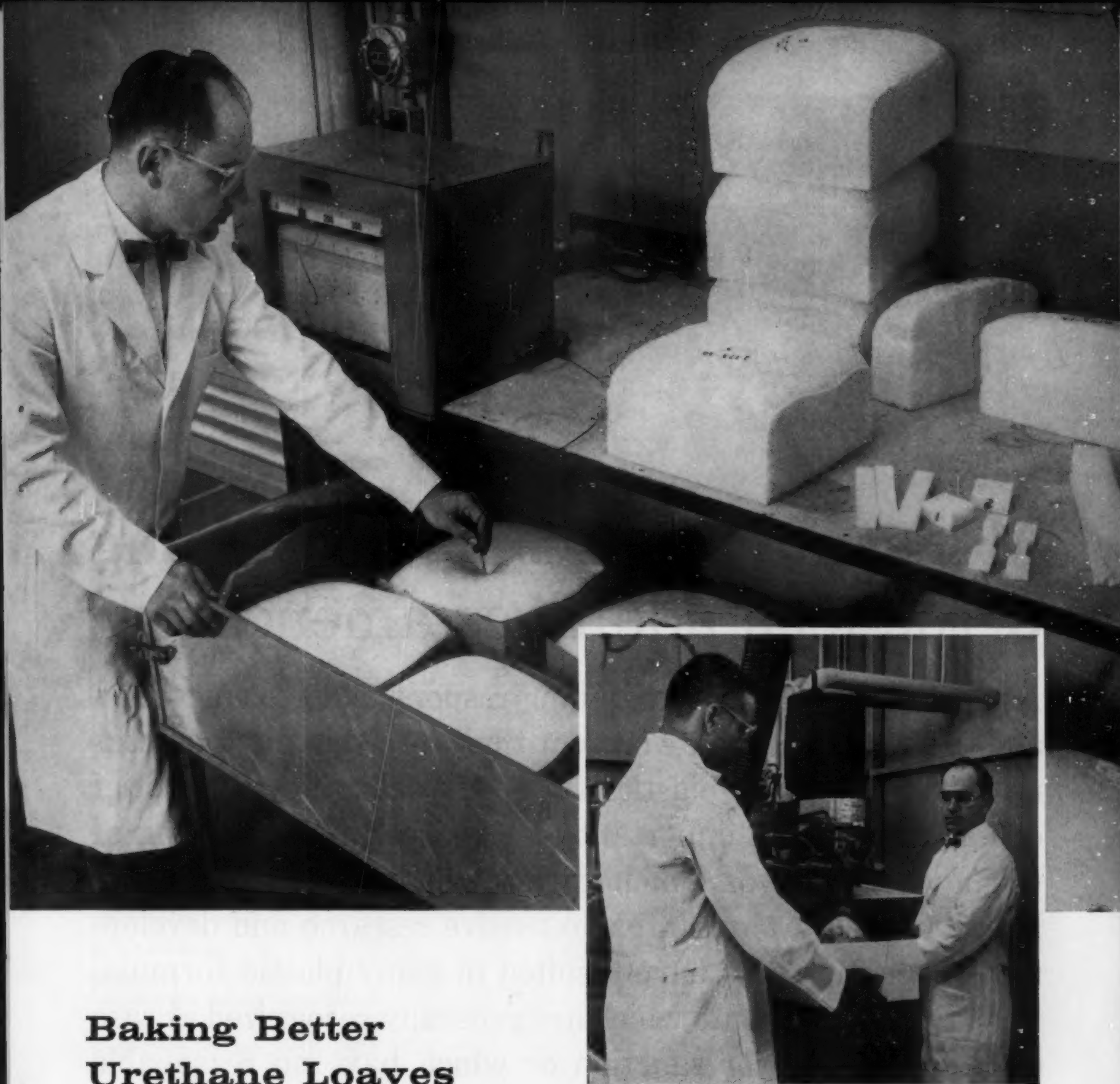
A ¾-mil film, developed by The Kordite Co., Macedon, N. Y., for use as innerwrap of bread previously packaged in wax paper alone, provides a ready-made bag in which the homemaker can keep the bread after the package has been opened. The new combination wax paper-and-poly innerwrap, which reportedly doubles life of freshness, can be merchandised to the consumer at an additional cost of less than 0.3¢ per loaf, according to Kordite.

Flexible magnetic tape

A new application of magnetized vinyl (See MPl, May 1959, p. 35) has been introduced in the form of a flexible vinyl tape into which finely divided magnetized particles are uniformly distributed, making the entire tape surface magnetic. Tradenamed Magnyl, the tape can be hot-stamped, embossed, laminated, printed, or silk-screened, and can be cut with scissors or die-cut to any desired shape, according to Applied Magnetics Corp., Leeds, Mass., producers of the tape. Magnyl is produced in stock sizes from 1/32 to ½ in. thick, in widths up to 2 in., in any desired length.

Seamless coating on tanks

Two tanks, 10 ft. in diameter by 15 ft. high, believed to be the largest ever coated with plastisol on the West Coast, have been seamlessly lined with Paraline



(Advertisement)

The Status of Monsanto Plastics—November, 1960

PRODUCTS	BASIS FOR RECOMMENDED USE IN FOOD PACKAGING
LUSTREX® STYRENE PLASTIC	
General Purpose Molding Grades	
Hi-Flow 55, Hi-Flow 77, Hi-Flow 66, Hi-Heat 99	Generally recognized as safe and prior sanction by FDA.
Impact Molding and Extrusion Grades	
Hi-Test 42 Type, Hi-Test 48 Type, Hi-Test 88 Type, Hi-Test 180 Type	Extension granted by FDA until March 5, 1961 (Long term feeding studies highly favorable)
MONSANTO POLYETHYLENE (NATURAL) (grades below)	Prior sanction by FDA.
VUEPAK® F CELLULOSE ACETATE	Generally recognized as safe and prior sanction by FDA.
OPALON® VINYL RESINS	
300, 300 FM, 330 FM, 410	Prior sanction by FDA.
Polyvinyl chloride acetate copolymers	
506, 510	Prior sanction by FDA.
SCRIPTITE®	
Paper and Paper Board Coating Resins	
50, 53, 52, 54	No reasonable expectation of migration when used as wax-holdout resin.
40 (Urea Resin)	Prior sanction by USDA Poultry Division as wet strength poultry package resin.
33 (Melamine Resin)	Prior sanction by FDA.
RESIMENE®	
883 (Melamine Resin)	Prior sanction by USDA Meat Inspection Division for lard cans.
U901 (Urea Resin)	Prior sanction by FDA.
LYTRON®	
Latex Paper Board Coating Resins	
6, 6-A	Not subject to regulation when used in single use disposable containers. Petition being prepared for regulation of all food packaging uses.
RESINOX® PHENOLIC RESIN	
P-97	Prior sanction by USDA Meat Inspection Division for lard cans.

MONSANTO POLYETHYLENE (NATURAL)

Injection and Blow Molding Grades		Film Extrusion Grades			Extrusion Coating Grades
51	805	30	37	18300	406
52	935	31	38	19706	537
60	9752	32	706	23406	73
80		33	10406	25706	
705		34	13406	26706	

DEFINITIONS

of terms important in understanding the Food Additives Amendment.

Food Additives Amendment—1958 Amendment to the 1938 Federal Food, Drug and Cosmetic Act. It requires, for the first time, that any chemical compound in food, whether intentional or incidental, must be proved safe before the food is put into interstate commerce. The amendment became effective March 6, 1960.

Food Additives—All chemical compounds in food are *not*, however, in *legal* sense food additives. Compounds with prior sanction or which are generally recognized as safe are specifically excluded by the new statute from the category of food additives.

Prior Sanction—Before the 9/6/58 enactment of the Food Additives Amendment, the Food and Drug Administration and divisions of the United States Department of Agriculture had only limited authority to approve use of chemical compounds in foods. Favorable response to a request for approval normally meant an informal letter of no objection—now classified as a prior sanction—exempt under the new amendment.

Generally Recognized as Safe—The FDA interprets this to mean that it is the widely held opinion of acknowledged authorities that a given chemical compound is safe in human food. FDA has published in the Federal Register, lists of compounds which are considered generally recognized as safe.

No Reasonable Expectation of Migration—It is obvious that chemical compounds not in food cannot be food additives. But the definition of "zero" content requires scientific judgment. No reasonable expectation of migration (of pharmacological significance) realistically recognizes that infinitesimally small amounts of certain chemical compounds may be and generally are present in processed foods without hazard.

* * *

A special report on food packaging colorants has been prepared for package manufacturers using colorants in their packages. For this report, write to Monsanto Chemical Company, Plastics Division, Room 773, Springfield 2, Massachusetts.

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RD polyvinyl chloride plastic by The Barber-Webb Co. Inc., Los Angeles, Calif. Oven cure is used. The coating material is a specially compounded vinyl plastisol made by Metal & Thermit Corp. The finished surface is said to be resistant to abrasion and impact as well as to acids, alkalies, salt water, and many other corrosives. The tanks are used to store sulfuric acid at mining operations.

PVC stabilizer

A new cadmium-barium liquid stabilizer called Metasap AB-62, is being produced by The Metasap Div., Nopco Chemical Co., Newark, N. J. It is recommended by the company for the stabilization of PVC film and sheeting, extruding and molding compounds, as well as plastisols and organosols for optimum balance between initial color and heat stability.

Chloride scavenger and extrusion aid

A low viscosity calcium stearate dispersion composed of 46% solids has been developed by The Harshaw Chemical Co., Cleveland, Ohio. The new dispersion is said to be a most effective chloride scavenger and polymer stabilizer in the manufacture of chlorinated polymers employing processes containing volatile solvents. It is also said to be an effective extrusion aid in plastics manufacture, and an internal and/or external lubricant in plastics molding.

Adopts urethane foam

The first line of nationally distributed urethane foam mattresses has been introduced by The Englander Co., Inc., Chicago, Ill. Englander is one of two mattress manufacturers whose products are nationally distributed. Urethane mattresses had previously found markets in institutional bedding applications (hospitals, naval vessels), but this is their first major penetration of the consumer market. Density of the foam is about 2 lb./cu. ft. Retail price is $59.75, for the twin size.

In manufacture, the ticking and borders are stitched directly onto the foam mattress core, eliminating the need for intertaping and preventing the cover from slipping. The mattresses are produced at Englander's 13 factories across the country, using foam furnished by several domestic suppliers.

The current total annual mattress market is 8 million units, of which only a small proportion is foam rubber. At present, urethane's share is infinitesmal. However, prospect for its replacing foam rubber mattresses are considered promising. According to Ira M. Pink, president of Englander, the new mattress also will compete strongly with the innerspring type and eventually make the innerspring obsolete.

Vinyl film prints

Calendered PVC films with multicolor (1 to 6) surface print, manufactured by Dynamit Nobel A.G., Troisdorf, Germany, and used by the novelty, notion, and handbag industries, have been added to the line of plastic products being marketed by Rubber Corp. of America, Hicksville, N. Y. Called Mipolam and Mipalette, these vinyl films were previously sold in the U. S. through Georg von Opel Corp.

More adhesives

Two new adhesives for cementing vinyl plastics to wood, leather, fabrics, and natural or synthetic foam have been developed by Adhesive Products Corp., New York, N. Y. Made from a latex polymer, the adhesives, designated Plastix Wet Stick, and Plastix Heat Seal, are said to be easily applied by roller coater, spray, or brush, and are available in 55-gal. drums and 1- and 5-gal. containers.

The Pan Am bag—a year later

The molded, high-density polyethylene flight luggage that created such a stir early this year (See "High-density PE breaks into luggage market with Pan Am flight bag, MPl, Oct. 1959, p. 92), is now reaching new markets.

The molder, Penn-Plastics Corp., Glenside, Pa., encouraged by the success of the original applications, has tried to find additional outlets—and succeeded. The basic bag, appropriately hot-stamped or decal-decorated, now goes into schools, Christmas packages, sales meetings, conventions, clubs, and the like. Current sales run about 2500 to 3000 bags a week and the price to schools in lots of 500 to 1000 is $1.25 per bag.

The bag is molded in two halves of Phillips Marlex material, the closures are molded of Rohm & Haas Implex modified acrylic.

License for coating pipe

Hill Hubbell Co., a division of National Malleable & Steel Castings Co., Cleveland, Ohio, has been licensed to use Republic Steel Corp.'s X-Tru-Coat process for coating steel pipe. The technique involves coating steel pipe with a specially developed adhesive and the continuous extrusion of a plastic jacket over it. The adhesive, which binds the coating to the steel pipe, remains "live," allowing the pipe to be flexed or bent without destroying the continuity of the coating, according to a company source.

Enters polystyrene field

Sterling Moulding Materials Ltd., manufacturer of phenolic molding powders, has begun production of polystyrene—under the tradename Sternite—at its newly expanded 220,000-sq.-ft. factory at Castle Mill, Stalybridge, Cheshire, England. At present the new material is made in two high-impact grades, ST.150—1.6 ft.-lb./in. notch; and ST.120—1.2 ft.-lb./in. notch, with plans to expand this range. Present production capacity is 4,000 tons. This is expected to be increased to 10,000 tons per year eventually.

Specialty processor

Growth of a plastics processor who concentrates on a specialty item is well illustrated by the annual statement of Resistoflex Corp., Roseland, N. J., which shows growth in gross profit from $1,601,658 in 1956 to $3,819,986 in 1960 despite a provision of $916,-500 for federal income taxes. During this same period net sales have grown from $5,687,465 to

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$13,227,713 and total assets from $3,483,662 to $7,812,111.

Resistoflex Corp. specializes in fluorocarbon processing for corrosion- and heat-resistant products. The company fabricates fluorocarbon pipe of from ½- to 10-in. diameters, which not only serves as pipe but can be used as a refraction column. Bellows and flex joints are now available in two constructions with diameters up to 8 inches. New products include convoluted tubing for carrying corrosive fumes or fluids, nozzle inserts, and heat-exchanger tube protectors.

For packaging bacon

A new packaging film, specifically developed for sliced bacon and said to be priced from 15 to 56% under competitive wraps, has been announced by the Packaging Films Dept. of The Goodyear Tire & Rubber Co. Called Vitafilm 75WNF-1, the new film is a 75-gage material, yielding 28,000 sq. in./lb., and is priced at .0255 cents/thousand sq. in., or 73¢/pound. It is available in rolls wound on a 6-in. core within a 9-in. outer diameter in any widths required for bacon packaging, and will be marketed in 500-lb. quantities, according to Goodyear.

Eliminates cooling cycle

Colab Resin Corp., Tewksbury, Mass., has developed a phenolic varnish, designated CR-301, which reportedly eliminates the need of a cooling cycle. Using CR-301 it is possible to press at 2000 to 3000 p.s.i. at shorter time cycles and to remove laminates without chilling the mold, resulting in laminates which do not blister, according to the company. Products made with CR-301 are claimed to have low moisture absorption, good chemcial resistance, and impact strength.

Glass fiber mats and tape

Pre-impregnated parallel glass fiber materials claimed to have high strength, lightweight features, and good heat resistance have been developed by Houze Glass Corp., Point Marion, Pa. Called Hi-Mod, the material is available in mats and tapes in two types. Type T has approximately 84% glass content impregnated with epoxy resin and is recommended for winding fabrication. Type S has approximately 78% glass content impregnated with modified epoxy resin and is recommended in honeycomb structures.

Grade 3 nylon balls

For industrial applications where close tolerances are not required, Ace Plastic Co., Jamaica, N. Y. extruder and fabricator, is now producing Grade 3 nylon balls in sizes from 3/32 to ¾ in. and larger, to commercial tolerances of ±0.065. Up to the present time, Ace had confined its production only to nylon balls with tolerances from ±0.001 on diameter, and ±0.0005 on sphericity.

Phenolic laminate

A new industrial laminate, which reportedly combines low cost with good self-extinguishing and electronic insulating properties, has been introduced by General Electric's Laminated Products Department. Designated NEMA type FR-2, the new material, Textolite 11586, is available in both standard and copper-clad sheets for printed circuits. The new laminate punches complicated parts cleanly at temperatures from 80 to 130° F. without cracking or undercutting and offers high uniformity, according to the company. The natural tan-colored material is translucent to facilitate circuit registration.

PVAc adhesives

Four new polyvinyl acetate wood adhesives for building, furniture, and assembly applications have been announced by the Resins & Chemicals Dept. of The Borden Chemical Co. The new adhesives, marketed under Borden's Cascorez tradename, are CV-735, a high-tack, high joint-strength emulsion for gluing operations where wet tack is essential; CV-731, a medium-solids, low-cost adhesive for applications where medium joint-strength is sufficient; CV-728, a medium-solids PVAc emulsion of fast setting speeds; and CV-737, a fast setting, high joint-strength adhesive with good freeze-thaw and storage stability.

The new adhesives are available in 30-gal., 55-gal., tank and truck car lots.

New cement for plastics

Proxseal adhesive No. 37-164-8 is a new addition to the line of special cements produced by Pyroxylin Products Inc., Chicago, Ill. It is claimed to be effective as either a wet-bonding cement or solvent-activated cement that can be used on vinyl, saran, pliofilm, rubber, and glass, as well as a variety of metallic materials.

Bronzeless gold spray

Bronzeless golds for thermoplastics, which simulate the appearance of fine bronze powders, are available in liquid form ready for thinning from Bee Chemical Co., Lansing, Ill. They are said to spray easily by hand or automatic spraying equipment, and long-term storage will not result in gellation, livering, or color change, according to Bee. Bronzeless golds are not recommended for outdoor applications.

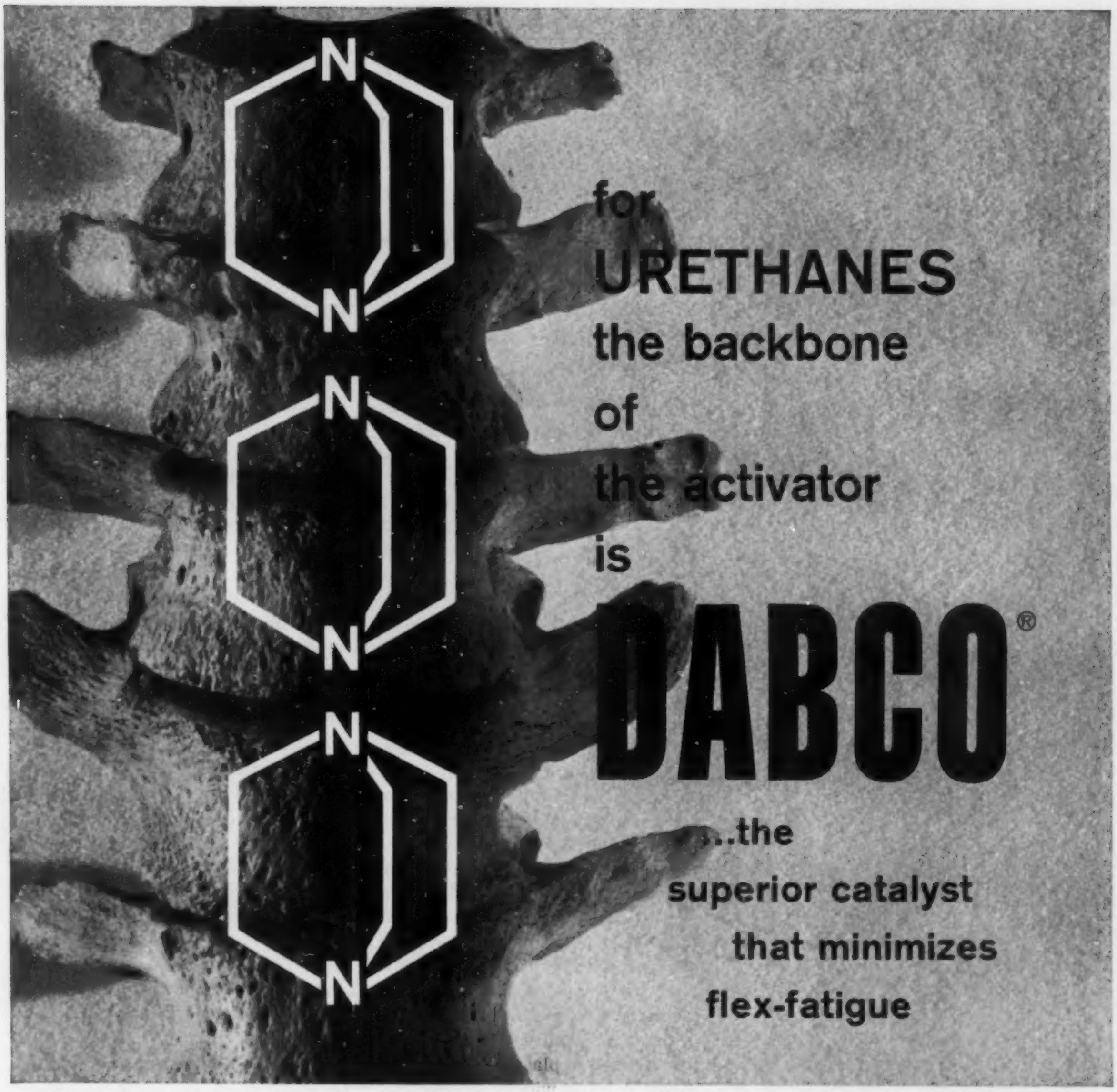
Styrene panels

Foam core sandwich panels have been introduced in the Pittsburgh, Pa., area by A. C. Schwotzer Inc., in the construction of five model homes. The panels feature a core made of Dylite expandable polystyrene, a product of Koppers Co. Inc., Plastics Div., and have been used during the past year in construction of model homes in various sections of the country.

Nu-Way polystyrene foam panels manufactured by United Progress Inc., Albany, N. Y., are now made with a special edge design that reportedly permits complete lapping of panels. They are available in thicknesses from 2 to 8 in., in both regular and self-extinguishing types.

Mold release agents

Mold Wiz Azn, a solvent type mold release for epoxy and isocyanate molding operations, has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for
URETHANES
the backbone
of
the activator
is
DABCO®
...the
superior catalyst
that minimizes
flex-fatigue

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been developed by Axel Plastics Research Laboratories, Brooklyn, N. Y. The material is presently available in 1-, 5-, and 55-gal. containers.

Partlube 100, a packaged universal release agent and mold lubricant, is currently available in aerosol containers from the British Industries Corp., Port Washington, N. Y.

Big polyethylene extruder

What is claimed to be the biggest polyethylene extruder along the East Coast, a 96-in.-wide machine that is capable of extruding PE films onto paper or board material, foil or film, recently was put into operation by American Sisalkraft Corp. The company plans to produce standard PE-coated materials as well as special grades on the new machine. The anticipated combinations will include vaporproof and greaseproof papers and boards for conversion packaging wraps, multiwall bags, folding cartons, in addition to general-purpose vapor barriers.

According to company officials, this is a step in a diversification program initiated several years ago. Present products include flameproof vapor barriers which can be used for pipe jacketing or duct lining or for the insulation facing for metal buildings, 3-color printing of laminated and reinforced paper, a plastic joint former which is being widely adopted by the construction industry, and other new products including a complete range of reinforced paper barriers and tapes.

Lauroyl peroxide

Commercial quantities of Truox Lauroyl peroxide are now available in 100-lb. drums from Thompson Chemical Co., Pawtucket, R. I. Lauroyl peroxide is widely used in plastics industries as a catalyst and activator.

Overwrap lamination

A laminated overwrap exclusive with the Flexible Packaging Div. of Continental Can Co. combines decorative brilliance with easy sealing product protection. Called Metacel Bencoseal, it consists of saran-coated cellophane which is reverse printed and then metallized for extra reflectivity. The resultant 0.003-in. film exhibits the characteristics of heavier, thicker aluminum foil laminations without their bulk or cost, according to Continental.

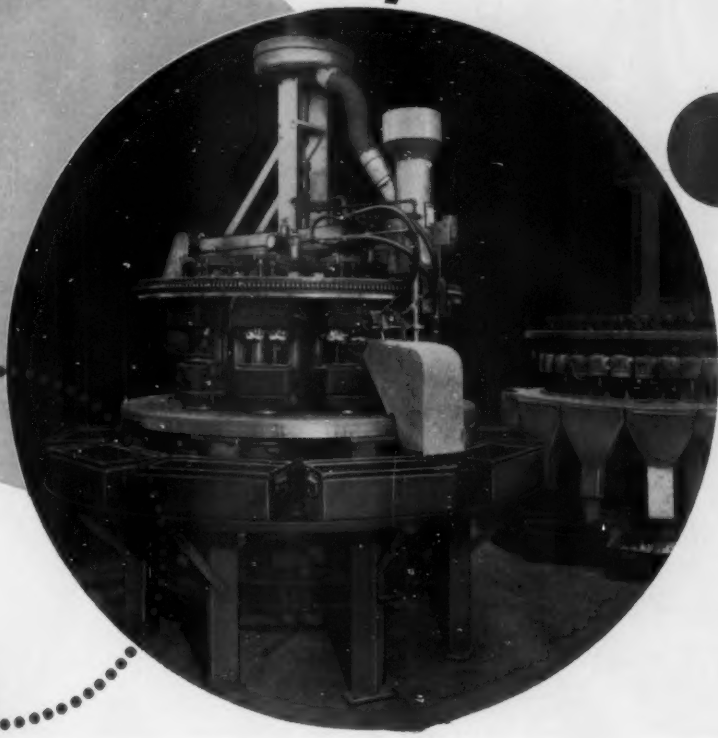
The company states that the saran coating assures a high degree of water vapor and abrasion resistance and the metallized coating adds brilliance, and that nitrogen-foamed margarine, cosmetics, and other oily products do not deteriorate when packaged in this new wrapping. Researchers found that dry milk solids also benefit from the low oxygen, nitrogen, and water-vapor transmission rate of the lamination. Even when creased, it does not break down because of its superior physical properties. It can be used on conventional overwrap machines. Roll stock of this material is available from Continental Can's Flexible Packaging Div., Mt. Vernon, Ohio, for testing.

New colors for vinyl film

Three new colors—mint green, medium blue, and white—have been added to the original silver metallic as standard colors in vinyl film facing for glass fiber and mineral wool insulation by The Goodyear Tire & Rubber Co. The color-decorated product is available in standard widths ranging from 38 to 54 inches.

Colored pearl essence

A new synthetic pearl essence, which provides color along with pearly lustre, has been introduced by the Mearl Corp., New York, N. Y. Called Murano color, it is available in formulations for surface coating and for incorporation into plastics. The material is said to provide multiple color effects which cannot be achieved with conventional colorants. While Murano colors react like conventional pearl pigments in all respects, they have twin inherent colors: one observed by reflected light, and the second seen by transmitted light. For example, a polyester cast sheet containing the red pigment appears red when held against a dark background and examined by reflected light,



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and appears green when viewed by transmitted light.

Colors such as gold, red, blue, green, and orange are now available. Multi-color effects may be obtained by using several colors in combination. The colors are rather subtle, and of moderate intensity, but the two-color play inherent in each pigment makes possible effects which cannot be otherwise achieved, and which verge toward iridescence, the company states.

Errata

On p. 1107 of the Modern Plastics *Encyclopedia Issue for 1961,* the name of Mr. David Wright, who authored the very comprehensive article on "Equipment for Fabricating Urethane Foams," was inadvertently omitted from the article. Mr. Wright, who is associated with The Falls Engineering & Machine Co., 1734 Front St., Cuyahoga Falls, Ohio —one of the country's leading producers of equipment of this type—is a recognized authority in this particular field.

In the "Foamed Plastics Chart" on p. 603, the name of Micron Chemical Products Corp., 740 Court St., Brooklyn 31, N. Y., should be included as manufacturers of chemically blown open-cell vinyl foam.

Hexyl alcohol

Enjay Chemical Co., a division of Humble Oil & Refining Co., has announced production of commercial quantities of hexyl alcohol at the company's Baton Rouge, La., oxo plant. Hexyl alcohol is used, among other things, as a raw material for plasticizers for developing polyvinyl chloride compounds.

Reinforced plastics

Mat for increased production. A fibrous glass, chopped strand mat, called Garanmat, claimed to wet out 3 to 5 times faster than other products now in the field, has been introduced by Johns-Manville. The new product, made of continuous-filament fiber glass roving to which Garan binder has been applied, is chopped into lengths of approximately 2 in., formed into a mat with random pattern, and bonded with plastic resins.

Extruded shapes. Glass-reinforced polyester extruded rod for insulating, structural, mechanical, or spacing members is available in nine special shapes from The Glastic Corp., Cleveland, Ohio. Cost for the various special shapes ranges from 6¢/ to 25¢/ft. depending on type and quantity that is ordered.

Spun glass roving for easier handling. Woven glass fiber roving made of spun glass fibers which reportedly retain greater flexibility than combed fibers used in conventional woven roving has been introduced by Sackner Products Inc., Grand Rapids, Mich. The result, according to the manufacturer, is a reinforcing material that cuts more easily and generally forms better in molding fibrous glass boat hulls, furniture, jigs and fixtures, or other shapes.

Glass for premix. A fibrous glass, chopped strand for reinforcing premix type molding compounds has been announced by Owens-Corning Fiberglas Corp. Designed for use in compression molding, the product, known as HSI, mixes in faster without clumping, improves compound flow, gives more uniform fiber distribution, and provides minimum surface distortion and rippling, according to the company. HSI is priced at 44¢/lb. and is available in ¼-in. lengths.

High dielectric premix. A glass polyester molding compound for molders of dielectric parts is available from The Glastic Corp., Molding Materials Div., Cleveland, Ohio. Called Glastic Grade 1703, the premix is said to have excellent dielectric strength, good impact strength, arc resistance, dimensional stability, and low water absorption.

Steel-reinforced polyester. A translucent fibrous glass panel featuring an embedded criss-cross pattern of ¾ in. expanded steel has been introduced by Alsynite

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Div. of Reichhold Chemicals Inc. Known as Gardlite, the panels are ⅛-in. thick, weigh approximately 18 oz./sq. ft., and are available in 4- or 5-ft. lengths in 48-in. widths. Translucent, but not transparent, the panels are said to be suitable for sheds, garages, storage rooms, warehouses, windows, etc.

New companies

Polystructures Inc., 41 Montvale Ave., Stoneham, Mass., has been formed to engage in research, development, and manufacture of reinforced plastics and foam plastics products. The new company will operate in the areas of encapsulation of electronic components, materials research, design and manufacture of radomes and plastic antennas, and plastic foam dispensing equipment. **M. M. Hannoosh** is president.

Zarn Inc., Reidsville, N. C., has been formed for the manufacture of blow molded articles and is currently producing stock polyethylene bottles and proprietary items. The company plans to mold with low- and high-density PE, other polyolefins, nylon, high impact polystyrene, etc. **C. J. Ammondson** is president.

Expansion

Federal Color Inc., Cincinnati, Ohio, has begun full-scale operation at its 60,000-sq.-ft. building on a four-acre site, part of its $1 million expansion program. The company manufactures both dry and flushed pigments for the plastic, paint, printing ink, rubber, and paper industries.

Devcon Corp., Danvers, Mass., has formed a special **Marine Div.** to service tankers, bulk carriers, and other ships requiring Plastic Steel compound for filling and repairing metal hull surfaces and pipe lines.

Rohm & Haas Co. is building a one-story, concrete-block warehouse, with 130,000 sq. ft. of floor space, at Bristol, Pa. The ware-


New Ideas in NYLON

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house will be used primarily for storage and shipment of finished products manufactured at the company's Bristol plant.

Celanese Corp. of America is constructing a multimillion-dollar unit in Bishop, Texas for production of 1,3-butylene glycol, a chemical used in the manufacture of vinyl plasticizers. The new facilities will have an annual capacity of 25 million lb. of chemical by a new process developed by Celanese. Construction of the new unit is expected to be completed in 1961.

Union Carbide do Brasil S. A., an affiliate of **Union Carbide Corp.**, is constructing an extension to its polyethylene plant located near Santos, Brazil, which will increase capacity from 9 million lb. to 24 million lb. annually. The project is scheduled for completion the latter part of 1961.

Phillips Petroleum Co. is constructing a 22-million-gal.-a-year plant to produce high-purity benzene at its Sweeny refinery near Houston, Texas. Benzene is a basic raw material for use in the plastics, detergent, synthetic rubber, as well as the synthetic fiber industries.

Alladin Plastics Inc., Gardena, Calif. injection molder, has acquired an additional 1½ acres of land with a 30,000-sq.-ft. building, giving the company a total of 130,000 sq. ft. of manufacturing area. The expansion will also include installation of two large preplasticating injection machines with a rated capacity of 130 oz. each.

American Pad & Textile Co., Greenfield, Ohio, has purchased the designs, patents, molds, inventory, and processes of **Bayshore Industries Inc.**, Elkton, Md. manufacturer of plastic marine items, such as rotationally molded vinyl ring buoys, blow molded PE boat fenders, and closed-cell vinyl foam ski belts. American Pad has several manufacturing plants and warehouses throughout the United States, and has the capacity for large-scale distribution of Bayshore-developed items.

Precision Plastics Co., Philadelphia, Pa. custom molder, has installed blow molding equipment, in addition to its present injection molding facilities.

U. S. Industrial Chemicals Co. has started construction of European technical service laboratory and sales offices. The new 24,000-sq.-ft. building, located in Baar, Canton of Zug, Switzerland, will be the headquarters of **U. S. Industrial Chemicals Co.-International**, which was formed in Nov., 1959. The technical service Laboratory, headed by **Howard W. Woodham**, is designed for polyethylene research.

Archer-Daniels-Midland Co. has broken ground for a multimillion-dollar chemical center at Peoria, Ill. The new plant, which is scheduled to go on stream in 1962, will manufacture many chemicals new to ADM as well as the company's established lines, which include plasticizers, esters, olefins, and other chemicals.

Imperial Chemical Industries Ltd. plans to expand existing capacity for vinyl chloride polymers at its Hillhouse Works, Lancashire, England, by 10,000 tons. Present capacity is about 70,000 tons. Completion of the extension is expected by mid-1961.

The Plastics Div. of I.C.I. is installing a plant to manufacture polyvinylidene chloride copolymers with production quantities to be available early in 1961.

Industrias Quimicas Argentinas Duperial S. A., a subsidiary of I.C.I., is planning construction of a polyethylene plant near San Lorenzo, Argentina, to be financed by the parent company at a cost of over $16 million. The plant will have an initial capacity of 10,000 tons per year, and Duperial will use the I.C.I. high-pressure polymerization process.

Mobay Chemical Co. is building additional facilities for the manufacture of tolylene **(To page 237)**

HARSHAW VINYL STABILIZER

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diisocyanate, to up its TDI capacity from 25 million lb. to 40 million lb. annually. This is Mobay's fourth major expansion of its New Martinsville, W. Va. TDI plant in five years. TDI is used in the manufacture of urethane foams, solid elastomers, and urethane coatings, and is Mobay's principal product.

Allied Chemical's Solvay Process Div. has announced a major expansion program which will approximately double facilities at the Syracuse, N. Y. research-technical service laboratory. The new facilities will allow for research in uses for propylene oxide polyethers for urethane foams and other applications, and organic compounds for the plastics and pesticide industries. Additional personnel required will bring the research group to approximately 230. Occupancy of the new project is tentatively scheduled for late 1961.

Bristol Aerojet Ltd., manufacturer of solid-fuel rocket motor cases and **Permali Ltd.,** supplier of reinforced plastic components, both English firms, have signed an agreement to collaborate in the manufacture and sale of filament-wound components.

Consolidated Zinc Proprietary Ltd. and **Monsanto Chemicals (Australia) Ltd.** have formed a joint company under the name of **Australian Fluorine Chemicals Proprietary Ltd.** The company's initial project will be the manufacture of fluorocarbons, which are expected to be in production in 1961. **H. B. Tribe,** currently production administration manager with Monsanto, will serve as the general manager of the joint company.

Stauffer Chemical Co. has brought on stream a new plant unit for the production of ultra-pure titanium trichloride at its **Anderson Chemical Div.,** Weston, Mich. Capacity of the new facility is rated at 500,000 lb. annually. Designated AA, the new grade of titanium trichloride is highly reactive. Its activity characteristics contribute to the compound's usefulness as a catalyst in the production of polypropylene.

Jefferson Chemical Co. Inc. has completed first-phase modifications and new construction on the former **Warren Petroleum Co.** plant in Conroe, Texas, acquired from **Gulf Oil Corp.** less than a year ago. The unit is currently producing polypropylene glycol and propylene oxide triols, chemicals that are used in the manufacture of rigid and flexible polyurethane foams.

The Fluorocarbon Co., Anaheim, Calif. producer of fluorocarbon plastics for aircraft, electronics, and space-missile industries, has purchased the assets of the Kel-F plastic division of **Raco Engineering Co.,** Santa Monica, Calif.

Vinatex Ltd. has built a new factory at Havant, Hants, England, for the manufacture of vinyl compounds, PVC pastes, and the recently-introduced Vinacoat PVC sintering powders for coating metal, glass, and porcelain articles by fluidized bed and other standard methods.

Unilever-Emery N.V., Gouda, Holland, has started operations in a new oleochemicals polymerization unit using a new process developed by **Emery Industries,** Cincinnati, Ohio, one of the parent companies of Unilever-Emery. Initially the plant will manufacture dimer acids and dilinoleic acids, chemical intermediates used in the manufacture of polyamide resins, polyurethane foams, alkyd resins, and other plastics.

California Chemical Co., subsidiary of **Standard Oil Co. of California,** is constructing a new complex of chemical plants at Standard's Richmond, Calif. refinery. The new complex is expected to produce enough para xylene to increase Richmond's annual output by 41 million lb. and will also provide more than 100 million lb. per year of high purity ortho xylene.

Para xylene is used in the man-

THE PLASTISCOPE

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ufacture of polyester fibers and films. Ortho xylene is used in the production of phthalic anhydride, used in the manufacture of alkyd resin paints, plasticizers, and unsaturated polyester plastics. Construction is expected to be completed late in 1961 or early in 1962. Output from the new units will be marketed by California Chemical's **Oronite Div.**, which was formerly known as the Oronite Chemical Co.

Synthane Corp., Oaks, Pa., has expanded industrial laminating facilities at its Glendale, Calif. plant with the installation of additional machinery and fabricating equipment.

Du Pont de Nemours International S.A., Geneva, Switzerland, is establishing a plastics design laboratory for development of new applications for Du Pont plastics. The laboratory will occupy two floors of a new seven-story building in Geneva, which will also house additional offices of the company. Completion of the new facility is expected in the spring of 1961.

General Foam Corp. has completed a 2-story, 50,000-sq.-ft., fully automated addition to its Hazleton, Pa. plant, thereby giving the company its first basic manufacturing facilities for urethane foam. Together with the adjoining 60,000-sq.-ft. plant, completed in 1957, the new unit provides the company with a continuous long production line, starting with raw chemicals and delivering finished foam in required forms and shapes for various industries. GFC also operates a 90,000-sq.-ft. processing and warehousing plant in New York, N. Y., where its executive offices are located.

Meetings

Plastics groups

Jan. 24-27, 1961: Society of Plastics Engineers Inc. (S.P.E.) Baltimore-Washington Section, 17th

masters

in the field of

COLOR

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Carved about 3300 years ago by an unknown master craftsman of Egypt, this elegant chair of state was found in the tomb of Tutankhamen. It is beautifully constructed of cedar wood and embellished with ivory and gold leaf. The central figure represents Eternity.

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Custom Compounders of Polyethylene Molding Powder and other Thermoplastic Materials
Manufacturer and Developers of Unicolor and Formacolor *Pliethene, Formacolor, Unicolor® T.M. Reg. U.S. Pat. Off.

THE PLASTISCOPE

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Antec, Shoreham Hotel, Washington, D. C.

Feb. 7-9: S.P.I. 16th Reinforced Plastics Div. Conference, Edgewater Beach Hotel, Chicago, Ill.

April 12-14: Deutsche Kunststoff-Tagung, Berlin, Germany.

June 5-9: S.P.I. 9th National Plastics Exposition and National Plastics Conference, Coliseum and Commodore Hotel, New York, N. Y.

June 9-17: European Congress of Chemical Engineering and ACHEMA Congress and Exhibition, Frankfurt am Main, Germany. Simultaneously, and in the same city, 15th Meeting of European Federation of Corrosion.

June 21-July 1: Interplas 61, 6th International Plastics Exhibition and Convention, Olympia, London, England.

July 27-Aug. 1: International Symposium on Macromolecular Chemistry, Queen Elizabeth Hotel, Montreal, Canada.

Other groups

Jan. 6: Akron Polymer Lecture Group, "Application of Differential Thermal Analysis to High Polymers," Room 107, Knight Hall, University of Akron, Akron, Ohio.

Jan. 16-20: National Housewares Manufacturers Assn. 34th National Housewares Exhibit, McCormick Place, Chicago, Ill.

Feb. 19-28: IPACK Biennial International Packing and Packaging Exhibition, Milan, Italy.

Feb. 26-Mar. 1: American Institute of Chemical Engineering 1st A.I.Ch.E. Petrochemical and Refining Exposition, Municipal Auditorium, New Orleans, La.

Mar. 27-31: 3rd National Symposium on "Temperature—Its Measurement and Control in Science and Industry," jointly sponsored by American Institute of Physics, Instrument Society of America, and National Bureau of Standards, will be held in Columbus, Ohio.—**End**


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COMPANIES . . . PEOPLE

Appointments, promotions, and relocations in the plastics industry.

AviSun Corp., producer of polypropylene polymer, film, and fiber: **Edwin M. Irish,** formerly product mgr.—polymer, named mgr.—sales; **Dr. E. T. Severs,** former product mgr.—film, appointed mgr.—market development. **Indio Braile** appointed to the international marketing div. of AviSun, which is jointly owned by **American Viscose Corp.,** and **Sun Oil Co.**

Modiglass Fibers Inc., Bremen, Ohio, **Div. of Reichhold Chemicals Inc.: Wolfgang C. Forster** appointed mgr., tech. service; **James E. DeFoor,** mgr., textile products.

Producto Machine Co., Bridgeport, Conn., has formed a **Plastics Machinery Div.** for the manufacture of blow-molding and sheet forming machines and equipment. Blow-molding units for the production of items up to 55-gal. capacity will be offered, the company states.

St. Regis Paper Co., Panelyte Div.: Fred Tyson transferred from Chicago, Ill., to sales office in Kalamazoo, Mich., replacing **Wendell Trest,** who transferred to Memphis, Tenn., office. **William Betken** named sales rep. for Decorative Panelyte, New York, N. Y., office, and **John P. LeGrand** is now the sales rep. Dallas, Texas, office.

Allied Chemical Corp. has combined polyethylene manufacturing and marketing with its other plastics and resins interests in a realigned **Plastics Div.,** formerly Plastics & Coal Chemicals Div.: **Roy L. Cammann** appointed sr. v-p; **Bennett D. Buckles,** v-p—sales; **James M. Maddox,** v-p—operations; and **Damon A. Peterson,** v-p—technical.

Kuhlman Plastics Co. Inc., Kansas City, Mo. injection molder: **Siebolt (Dutch) Hettinga** appointed v-p, engineering; **John E. Ferguson** named v-p, sales.

Sinko Mfg. & Tool Co., Chicago, Ill., has added a new 90-oz. preplasticating plastic molding press to its expanding line of molding equipment.

Flexible Tubing Corp., Guilford, Conn.: **Raymond J. Love** named plant mgr. **Robert Watkins** named gen. products sales mgr. for Ohio, Mich., and western Pa.

Extrudo-Film Corp.: Joseph S. Persaud named Midwest sales mgr., **Harold R. MacHenry** appointed asst. Midwestern sales mgr. with headquarters in the Chicago, Ill. office. **Ronald Newton,** formerly with N & N Plastic Extruders, recently acquired subsidiary of Extrudo-Film Corp., appointed sales mgr., Southwestern states.

Hercules Powder Co., Wilmington, Del.: **Elmer F. Hinner** and **John M. Martin** elected v-p's. Mr. Hinner has been gen. mgr., cellulose products dept., since 1954, and has had responsibility for the company's rapid development in polyolefins. Mr. Martin has been gen. mgr., explosives dept., since 1953, and has been responsible for establishment and growth of Hercules' chemical propulsion div.

Charles A. Grant named dir. of sales, and **Arloe R. Olsen,** asst. dir. of sales of the company's **Virginia Cellulose Dept.**

Taylor Fibre Co., Norristown, Pa.: **Harry L. Hildebrand,** formerly mgr., **Fabricating Div.,** named to newly created position of mgr., process and design engineering. **John G. Musselman Jr.,** formerly with SKF Industries, appointed mgr., Fabricating Div.

Miller-Stephenson Chemical Co. Inc., S. Norwalk, Conn.: **Arthur Seger Jr.** elected v-p, **Peter C. Rumery** appointed tech. sales rep. The company is a distributor-producer of epoxy products and adhesives, polyester resins, fiberglass-cloth-mat, and related materials for the electronics, aircraft, marine, molding, and other resin-consuming industries.

Society of Plastics Engineers Inc., Stamford, Conn.: **Frank W. Reynolds,** mgr. of **IBM's Plastics Laboratory,** Endicott, N. Y., elected pres. for 1961; **James R. Lampman,** mgr., **Organic Chemical Engineering Materials & Process Lab., General Electric Co.,** Syracuse, N. Y., elected v-p, engineering; **John Delmonte,** pres., **Furane Plastics Co.,** Los Angeles, Calif., is v-p, administration. They will take office Jan. 25, 1961, at the Society's Annual Technical Conference, which will be held in Washington, D. C.

Pacific Moulded Products Co., Los Angeles, Calif.: **Norman A. Klemp,** plant mgr., named v-p. **William Long** appointed tech. dir. in charge of research and laboratories.

The Dow Chemical Co.—Plastics Dept.: Corliss F. Cummins named asst. sales mgr. He is succeeded by **H. P. Morand** as mgr., molding materials sales. **John E. Donalds** named mgr. of coatings sales, succeeded by **Charles W. Cairns** as plastics dist. sales mgr. in the Detroit, Mich. office.

Dobeckmun Co.: Sam H. Zutler named sales mgr., Saran Wrap-S products. He will work under the direction of **Paul R. Collins,** former sales mgr. for Saran Wrap-S products, who has been placed on special assignment.

Rez-Coat Sales of California established a northwestern regional office at 1825 N. Highland, Tacoma, Wash., for the distribution of its impregnated papers and fabrics, under the direction of **Richard L. Rose.**

Dura Process Co., mfr. and processor of Mylar and vinyl name plates and trim materials for commerce and industry, recently moved its entire operation to larger quarters at 2011 Washington Ave. N., Minneapolis, Minn.

Du Pont Co.—Film Dept.: Dr. John P. Wilkins appointed mgr., industrial market development, succeeding **Daniel D. Lanning,** who died recently. **J. Thomas Axon** appointed asst. mgr., industrial sales, succeeding Dr. Wilkins.

Herman Muehlstein of **H. Muehlstein & Co.** was honored at a dinner given by the newly formed Plastics and Allied Industries Div. of United Jewish Appeal, for his efforts in organizing the group and for his many years of outstanding humanitarian service. Contributions by the guests were announced totaling $250,000 to the 1960 relief and resettlement campaign of the UJA.

B. F. Goodrich Chemical Co.: Walter S. Lodge and **Ralph E. Koester,** former plastic materials sales reps., promoted to area marketing reps., a recently created sales management position.

W. K. Woodruff joined **Convention Sales Corp.,** Chicago, Ill., after many years as Chicago rep. for Celanese Corp. of America. Mr. Woodruff built up a wide acquaintance in the Midwest and was instrumental in making arrangements for S.P.E. and S.P.I. affairs including the National S.P.I. Conference in Chicago in 1958. In his new connection, he is still working closely with S.P.I. and other industry groups in setting up meeting arrangements at hotels in the Chicago area.

Frederick N. Collins appointed dir., new product development, for **Dyna-Foam Corp.,** Ellenville, N. Y. producer of extruded expanded polystyrene products. Dyna-Foam

COMPANIES...PEOPLE

(From page 242)

Corp. is a subsidiary of the **Sun Chemical Corp.**

George R. Vila elected pres. and chief operating officer of **U. S. Rubber Co.**, succeeding **John W. McGovern**, who retired after 40 years of service in the company. Mr. Vila comes to his new post after three years as group executive vice-president responsible for operations of the Naugatuck Chemical, textile, international, and plantation divs., as well as the subsidiaries **Dominion Rubber Co. Ltd.** (Canada) and **Latex Fiber Industries Inc.** He was formerly a v-p and gen. mgr. of the company's **Naugatuck Chemical Div.**

G. R. Vila

John H. Jackson Jr. appointed national sales mgr. of **Malco Plastics Inc.**, Baltimore, Md. producer of plastic credit cards and related printed and laminated products.

Clinton J. Starke appointed plastics engineer in the decorative laminate group of **Food Machinery & Chemical Corp.**'s Applications Tech. Service Lab., Baltimore, Md.

David Markowitz, formerly with Koppers Co., Butadiene Div., appointed asst. mgr., **Polymer Div., Foster Grant Co.,** Leominster, Mass.

General Aniline & Film Corp. has organized three new divisions headed by the following gen. mgrs.: **Dr. C. C. Schulze, Antara Chemicals Div.; Joseph W. Conlon, General Dyestuff Div.; Robert J. O'Brien, Collway Pigments Div.** The newly organized divisions, with headquarters located in New York, N. Y., formerly comprised the Dyestuff & Chemical Div.

H. A. Captein appointed sr. sales rep., San Francisco, Calif. office, for **The Goodyear Tire & Rubber Co., Chemical Div.**'s line of synthetic rubbers and vinyl resins.

Dr. W. J. Belanger named dir., resin development, of **Jones-Dabney Co.,** div. of **Devoe & Raynolds Co. Inc.,** Louisville, Ky. He is succeeded by **W. F. McWhorter** as mgr., plastics tech. service lab. Devoe & Raynolds Co., producer of plastics and resins, paints, and industrial finishes, is a subsidiary of **Merritt-Chapman & Scott Corp.**

Francis R. DiFranco appointed mgr., **Hydro-Chemie Div., Conapac Corp.,** New York, N. Y. He will represent Hydro-Chemie Ltd., Zurich, Switzerland mfr. of thermoforming machinery.—**End**

CLASSIFIED ADVERTISEMENTS

EMPLOYMENT • BUSINESS OPPORTUNITIES • USED OR RESALE EQUIPMENT

Machinery and Equipment For Sale

FOR SALE—3 PLASTIC INJECTION Molding Machines, $10,000.00; 9 oz. HPM Model 250 H9, Ser. No. 45-517; 9 oz. HPM Model 250 H9, Ser. No. 49-9; 24 oz. 1945 Watson Stillman, Model Y3296. Call or write: National Products Company, BEnton 1-7811, 6100 Wilson Ave., Kansas City, Missouri.

FOR SALE—1 Model SF-70 Sealomatic, pneumatically operated press with Model 3000—30 KW generator. Bed size 24" x 60" x 24" deep-operating pressure 10,000 lbs., complete with air, safety and electrical controls. (1) Brown Machine Company Model 222 Thermoforming machine, bed size 32" x 60" x 18" deep with top and bottom moving platens. Complete with heaters, cooling fans, air and electrical controls. Both machines new, in original crates, sold as unit or separate. Reply Box 6764, Modern Plastics.

FOR SALE—Baker-Perkins size #15-UUMM, 100 gal. jktd. dispersion mixer, 100 HP, compression cover, motorized tilt. 1800 gal. T316 SS jktd. & agit. reactor. #3TH mikro pulverizers. Stokes #R tablet press. Buflovak vacuum shelf dryers. Perry Equipment Corp., 1429 N. 6th St., Phila. 22, Pa.

FOR SALE—2 GIRDLER STAINLESS STEEL 4" x 48" Single Barrel Votators equipped with chilling unit and Sierbath high pressure pump. New condition. One 3" x 12" Votator with chilling unit & Moyno Pump. Campbell levelling and splitting machine. 64" x 96" bed, with polyurethane guide bar, double input compression roll, dual motorized blade sharpener, and abrasive table top, used very little. Reply Box 6770, Modern Plastics.

FOR SALE—2 DUNNING & BOSCHERT 300-ton compression molding presses; 1 Stokes model R-4 preform press; 3 Ball & Jewell granulators, 15, 10, 7½ HP; 2 self-contained compression molding presses, 75 and 150 tons; 1 Cumberland 7" stair step dicer, stainless steel. Chemical & Process Machinery Corp., 52 9th Street, Brooklyn 15, N. Y. HY 9-7200.

MOST MODERN PACKAGING AND PROCESSING MACHINERY Available at Great Savings. Baker Perkins, W & P. and Day Double Arm Steam Jacketed Heavy Duty Mixers—25, 50, 75, 100, 150 and 200 gal. capacities. Day, Robinson 50 to 10,000 lbs. Dry Powder Mixers, Jacketed and Unjacketed. Also wood and Enamel. H. K. Porter 650-gal. Steam Jacketed Double Spiral Mixers. Day Imperial 75-gal. Double Arm Mixer, Sigma, Dispersion Blades. Mikro Pulverizers, Model Bantam, 1SH, 2TH, 3TH and 4TH. Fitzpatrick Models D, K-7 and K-8 Stainless Steel Comminuters. Stokes Models R, RB-2 and Eureka Tablet Machines. Colton 2RP, 3RP, 3B, 5½ T Tablet Machines. Stainless Steel Jacketed Mixing Ketties 100 and 150 gal. capacities. Robinson Stainless Steel Double Arm Mixer for dry and viscous materials. Package Machinery, Hayssen, Scandia, Wrap King, Campbell, Miller Wrappers. Cartoning Machines—Ceco, Pneumatic Scale, Jones. Filling Machines—all types and sizes. UNION STANDARD EQUIPMENT COMPANY, 318 Lafayette Street, NEW YORK 12, N.Y. Phone CAnal 6-5333.

FOR SALE—TOLEDO FLOOR SCALE Never used—Still in original crates. 38" x 46" Platform, 20" Dial, 2 Beams, gross capacity 2800 lbs. Model #2151 cost $1658.71. Will sell for 25% off list. The Marblette Corporation, 37-31 30th Street, Long Island City 1, New York, STillwell 4-8100.

FOR SALE—(1)—REIFENHAUSER 63" Chill Roll Unit. (1)—63" Die for above unit. (1)—60" Beck Slitter. The above equipment is unused, and still crated. It has never been used. Ready for immediate shipment. Priced to sell. Reply Box 6753, Modern Plastics.

SUBSTANTIAL SAVINGS ON GOOD EQUIPMENT—(6) Stokes Self Contained Molding Presses 150 ton with 3 HP. Hydr. Pump system. (2) HPM Self Cont. 25 ton; 18" Stroke, 40" Daylt. (1) HPM Self Cont. 7 ton Press: 12" Stroke S.B. 450 ton Press with 36" x 36" Platens. F.B. Unused 2 Roll Mills, 14" x 30" Uni-Drives. 2 Roll Mills, 12" x 24" and 22" x 60". 3 Roll Calender, 22" x 58" with accessories. Baker-Perkins Dbl. Sigma Arm, Jktd. Mixers to 300 gal. Day 150 gal. Jktd. MOGUL Mixer, Vac. Cover, 75 HP Brand New FALCON Dbl. Ribbon Mixers; all sizes Extruders: NRM 1½", Royle 2", Hyd. Strainer 15". Stokes Preform Presses (3) #280, (1) #252 Colton #5½ T Single Punch Tablet Press, Ball & Jewell Rotary Cutters (2) #2, (1) No. 1 Sprout Waldron Rotary Cutter 15 H.P. Inquire about the FMC Rental-Purchase Plan. FIRST MACHINERY CORP., ST. 8-4672, 209-289 Tenth St., Bklyn. 15, N.Y., Cable "Effemcy".

FOR SALE INJECTION MOLDING MACHINES—24 oz. Watson Stillman, fitted with 100 oz. PrePlasticizer. Complete with all controls. Also available 12 oz. DeMattia and 8 oz. Reed Prentice Dual Link Type. TRANSFER MOLDING PRESSES—300-Ton Stokes with Bristol Timers and Dual Pumping Systems. Two available. 100-Ton and 80-Ton sizes also available. MULTI-OPENING PRESSES—600-Ton Adamson with Eight 42" x 42" steam heated platens. Presses from 24" x 24" up to 30" x 60" with four to ten openings each. We carry a complete line of scrap grinders, extruders, mills, calenders, preheaters, tablet presses, Banbury Mixers and other equipment for the plastic trade. Liquidations our specialty. What do you have for sale? We will finance your purchases. Johnson Machinery Company, 90 Elizabeth Avenue, Elizabeth, New Jersey, ELizabeth 5-2300.

FOR SALE—WATSON-STILLMAN 240 ton, ten 24" x 56" Platens. W. & W. 200 ton 24" x 42". Stokes Standard 50, 100, and 150 ton Semi-Automatics. Baldwin 150 ton, 30" x 20" self contained. D & B 150 ton, 25" x 25". French Oil 120 ton self-contained. 120 ton Upstroke, 29" x 21", 10" stroke. 50 ton Birdsboro 24" x 20". Stokes 15 ton automatic. Hydraulic pumps and accumulators. MPM 3½" wire covering Extruder. New ¾" Plastic Extruder. Other sizes up to 6". Seco 6" x 12" and 8" x 16", 2—Roll Mills and Calenders and other sizes up to 60". 60" Spreader Heads with XP motors. Despatch electric heated ovens and other types. New ¾ oz. Bench Model Injection Molding Machines. Van Dorn 1 and 2 oz. Other sizes up to 100 oz. Baker-Perkins and Day Jacketed Mixers. Taylor-Stiles Pelletizer, 7½ HP. Plastic Grinders. Stokes RD3 and R Machines. Send for listings. We Buy Your Surplus Machinery. STEIN EQUIPMENT COMPANY, 107 8th Street, Brooklyn 15, New York.

JAPANESE BLOWING MACHINE, made by Kato. Machine has never been run. Price $2,000.00. Where is, as is. Subject to prior sale or withdrawal of sale. Address: Great American Plastics Company, 650 Water Street, Fitchburg, Massachusetts.

PLASTIC BLOW MOLDING MACHINES—New imported at sensational low prices. Large machine with 3 inch extruder delivered N.Y. duty paid $3800.00 others from $2000.00 to $5500.00. Sole U.S. distributor. Kroll Trading Co., 133 Greene St., N.Y.C. Or 4-1414.

FOR SALE—BANBURY MIDGET mixer; 1-Farrell Birmingham 8" x 16" Chrome Plated 2-Roll Mill; 1-Baker-Perkins 10 gal. 304 SS Sigma Blade Mixer; 1-Baker-Perkins 100 gal. Sigma Blade Mixer; 1-Baker-Perkins size 16 TRM 150 gal. double arm Vacuum Mixer; 1-No. 1 Ball & Jewell Rotary Cutter; 2—Mikro Pulverizers, SS Bantam, #1 SH. 6—Stokes Model DD2, DS3, D3, and B2 Rotary Preform Presses, partial listing; we purchase your surplus. Brill Equipment Co., 35-65 Jabez St., Newark 5, N.J. Tel: MArket 3-7420.

FOR SALE—Two Reed Prentice injection molding machines, model 10D-12 oz. (1954) complete with instruments, controls, etc. for immediate removal. Both machines are in excellent condition and priced reasonably. Call, write or phone for appointment to see in operation before removal. Ask for John Krach. Rogers Plastic Corporation, West Warren, Mass. HEmlock 6-7744.

DUPLEX SLITTER—Brand new—57" wide, suitable for slitting rolls ⅜" or wider, any non-elastomeric plastic .001-.040—finished diameter 10". Alternate rolls rewind on opposing shafts eliminating any interlocking. Price $1350. Reply Box 6777, Modern Plastics.

FOR SALE—6 Inch Extruders electrically heated, 24-Inch All-Steel Granulator, 6-Inch Rubber Strainers, 18-inch Cumberland Granulator. Dual-Head Blow-Mold Machine. All in Perfect Condition. Rego, Inc., 830 Monroe St., Hoboken, N. J. OL 6-2020.

FOR SALE—3300-TON TWENTY-DAY-LIGHT Board Press, steam heated platens 12'6" x 4'6", with mechanical loaders and unloaders; self-contained pumping unit; excellent equipment fully reconditioned. Reed Brothers (Engineering) Limited, Repland Works, Woolwich Industrial Estate, London S.E. 18., Cables REPLANT London.

Machinery Wanted

WANTED—Used late model 3½" plastic extruder. Will pay top price for immediate delivery. Can use late 2½" model also. Give hp, L-D ratio and mfgr's name and serial number. Reply Box 6768, Modern Plastics.

WANTED—Late model HPM 20 ounce or 32 ounce preplasticizer must be model P80 or later. American Molded Products Co., 2727 W. Chicago Avenue, Chicago 22, Illinois.

LABORATORY AND PLASTIC testing equipment wanted. Extruder 1"-1½". 20-1 L/D ratio, Impact tester, Impact notch cutter, Shore D hardness tester, Heat distortion tester, Melt index tester, Tyler Ro-tap sieve shaker, constant temperature water bath, analytical balance & weights and etc. Reply Box 6763, Modern Plastics.

Materials Wanted

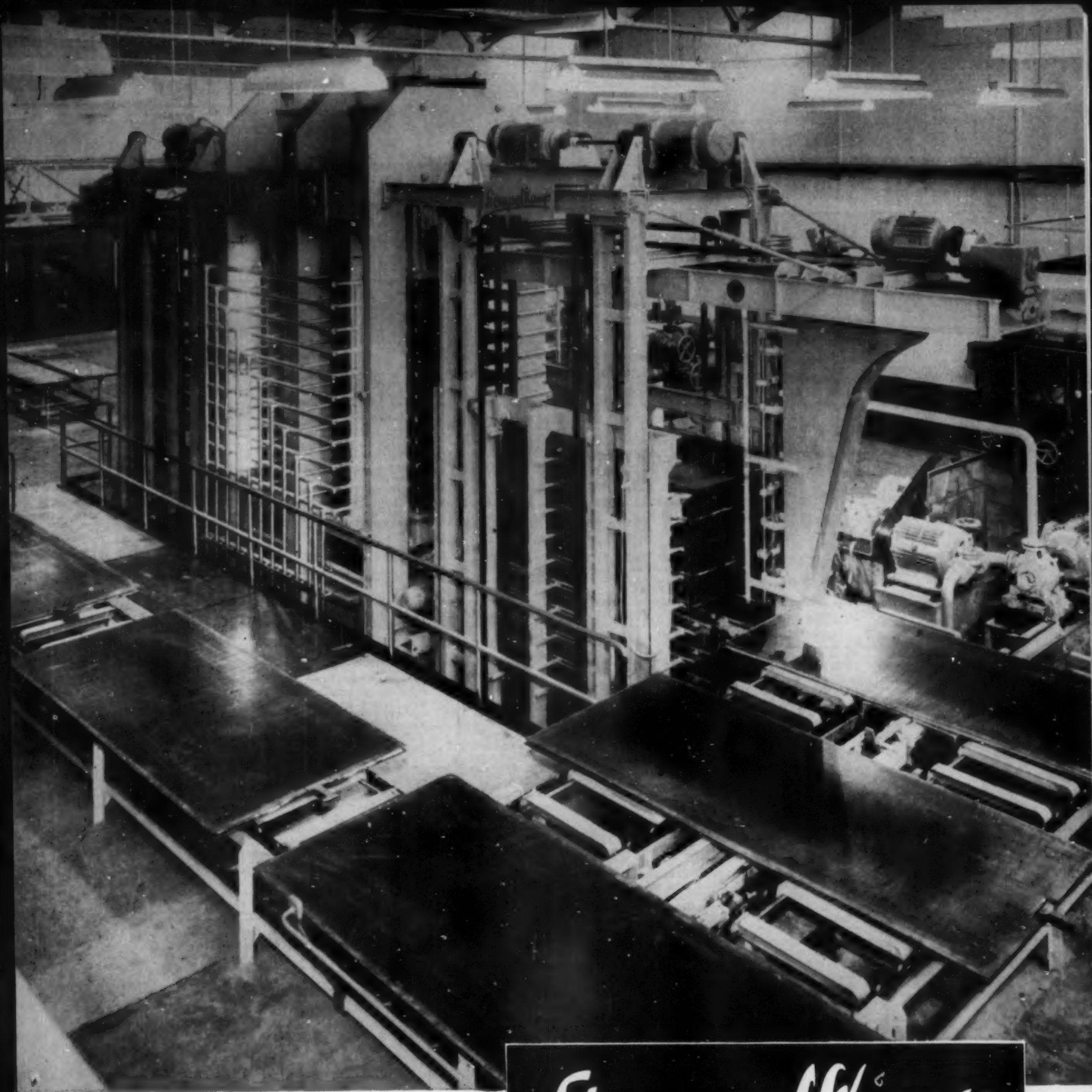
PLASTIC SCRAP WANTED—Styrene, polyethylene, butyrate, acetate, vinyl, nylon, etc. Lumps, reground, virgin lots, off grade, molded parts etc. We also have large inventories of virgin and reprocessed materials to offer at realistic prices. Universal Plastics Corporation, 15 Third Street, Passaic, N.J. PRescott 3-0370.

PLASTIC SCRAP WANTED: Sell us your year end surplus inventories of plastic scrap or surplus molding powders of: Acetate, Acrylic, Styrene, Butyrate, Polyethylene, etc. in any form. Write, wire or phone collect: Philip Shuman & Sons, 571 Howard St., Buffalo 6, New York. Tele. TL 3-3111.

WANTED—Polyethylene, styrene, polypropylene scrap in any form. Also surplus lots. Top prices paid. Chemsol, Inc., 68 Clifford St., Newark, N.J. MA 3-7515.

GET THE TOP MONEY FOR PLASTIC SCRAP—Now paying top prices for all thermoplastic scrap. Wanted: polystyrene cellulose, acetate, vinyl, polyethylene, butyrate, acrylic nylon. All types and forms including rejects and obsolete molding powders. Fast action wherever you are located. WRITE, WIRE, TODAY! Reply Box 6675, Modern Plastics.

(Continued on page 248)



(Continued from page 246)

Materials For Sale

FOR SALE—Several tons No. 516-L Absorbent Paper (Hurlbut Paper Company); sheet size—19¾ x 22¼. Box No. 6772, Modern Plastics.

FOR SALE—Polypropylene, natural, black and other colors. E/C shiny black pellets. Acrylic, clear regr. 1st grade various formulations. 3800 lbs. virg. standard transp. red Acrylic. Reply Box 6766, Modern Plastics.

SURPLUS POWDERS—STYRENE—43,500 lbs. Hi. Imp. Util. Black; 52,200 lbs. Med. Imp. Util. Black; 37,400 lbs. Gen. Purp. Util. Black; 49,700 lbs. Gen. Purp. Hi. Luster Black. Polyethylene—96,000 lbs. M.I. 2, Low Den., Black. Butyrate—21,000 lbs. Black. Acetate—29,000 lbs. Black. Very attractively priced depending on quantity ordered. Reply Box 6771, Modern Plastics.

FOR SALE—SCRAP GLASS FIBERS—Large quantity of scrap glass fibers for sale in mat form. Variety of widths, weights and binders. If interested, contact Box 6765, Modern Plastics.

Molds For Sale

MOLDS (INJECTION) FOR SALE—All in excellent condition, ready for molding housewares, containers and covers. Some are brand new (duplicate), some are discontinued items. Will fit 8 and 12 oz. machines. Priced to move. Rogers Plastic Corporation, West Warren, Mass., HEmlock 6-7744.

Help Wanted

ESSO RESEARCH & ENGINEERING is intensifying its activities in applications research and new petrochemicals development. A number of excellent research staff positions have been created in our Chemicals Research Division for Chemists and Chemical Engineers of all degree levels and with 2-6 years experience. THERMOSETTING RESINS: Compounding, formulation, and fabrication research on new thermosetting resins for such applications as glass and paper reinforced laminates, encapsulation and molding compounds. Work with new Buton resins in both laboratory applications and field contact with market development personnel. THERMOPLASTICS: Product and applications research on new thermoplastics, including polyolefins. Experience desirable in evaluation of new materials and techniques, operation of plastics processing equipment, compounding and testing of products for such fields as film, extrusion coating, pipe, wire coating, blow molding, flame spraying, and monofilament. Association with ESSO offers excellent opportunities for personal advancement, professional growth, publication of papers, and participation in technical society activities. Forward replies in complete confidence to Mr. C. D. Gardei, Professional Employment—Dept. V. ESSO RESEARCH & ENGINEERING CO., P.O. Box 175, Linden, N. J.

EXPERIENCED CHEMIST OR CHEMICAL ENGINEER to fill a challenging new position in market development for urethane elastomer materials. Mobay is fast-growing associate company of Monsanto with four major plant expansions in past five years. Small company flexibility with big company advantages. Pittsburgh location. Excellent opportunities for advancement. Send resume in confidence to: Director of Personnel Relations, Mobay Chemical Company, Penn Lincoln Parkway West, Pittsburgh 5, Pa.

SALES MANAGER to head aggressive, blow molded plastic container organization aiming for high quality, low price, volume trade, for detergent, cosmetic and similar industries. Well financed and have latest, high speed equipment. Salary plus participation offered. Plant located in New York City area. Reply Box 6767, Modern Plastics.

SALES MANAGER—Dynamic man to establish and manage sales program for a custom injection molding plant. Must be experienced. Send resume and salary requirements. DuBois Plastic Products, Inc., 170 Florida St., Buffalo 8, N.Y.

SALES ENGINEER EXTRUSION MACHINERY—Our expansion program provides an opportunity for an experienced man in our sales organization preferably with some knowledge of plastic extrusion. All applications held in confidence. Please write giving experience, education & salary requirements to, E. R. Coddington, Sales Manager, Waldron-Hartig Division of Midland Ross Corp., P. O. Box 531, Westfield, New Jersey.

WIRE & CABLE PLANT MANAGER—We want a man with plastic extrusion experience to run a large New Jersey insulation plant. Work includes scheduling, foreman supervision, production evaluation, general problems of plastic extrusion and copper wire drawing. This is a growth opportunity for alert, aggressive imaginative man. Write stating experience and salary requirements. Reply Box 6751, Modern Plastics.

ADHESIVES ENGINEER—Chemist or CE. Experienced. To head up research, development and production of adhesives for ceramics, flooring, structural and specialty items. Salary open. Established growing company in Western Pennsylvania. Reply in confidence to Box No. 6754, Modern Plastics.

ESTABLISHED MANUFACTURER in South East Massachusetts seeks services of young, vigorous manager to take complete charge of division manufacturing resin-compression-molded products. Practical experience required. Must have leadership drive, organizational ability, and the ability to handle labor. Send all details in confidence to President, Box 6761, Modern Plastics.

MANAGER for Custom Profile Extrusion Division. Requires knowledge of profile die design, extrusion techniques and ability to deal with and advise customers, as technical service is required. Salary and Bonus commensurate with experience and ability. Reply to: Mr. J. Van Dyke, President, Western Textile Products Co., 2131 Hickory St., St. Louis, Mo.

WANTED—Production Manager for medium sized, well established plastic extrusion plant; salary potential in middle five figures. Successful applicant must have thorough knowledge of machines, materials, personnel, costs and estimates, and the ability to secure and maintain production. Liberal vacation plan and fringe benefits offered. Please submit complete resume covering availability, age, education, experience and photo to Box 6757, Modern Plastics.

MOLD DESIGNERS—Mattel's continued expansion has created a position for an experienced injection mold designer. This position requires a young man capable of designing molds for all types of toys and conducting liaison with vendors. Previous experience in the toy industry preferred. MATTEL, a progressive, growing company, offers challenging assignments, excellent fringe benefits and a starting salary commensurate with background. Send resume and available sample prints to: MATTEL, Inc., 5150 Rosecrans Ave., Hawthorne, California. (Southwest Los Angeles Area)

EXPANDING FAST MOVING midwest molding company needs top notch engineer with injection molding background. Also need man heavy in injection molding procedures to handle night shift. Both these jobs are a real opportunity with possibilities of rapid advancement. Location Central Indiana. Reply Box 6752, Modern Plastics.

WANTED — MANUFACTURER REPRESENTATIVES—New aggressive custom molder with latest high speed equipment and tooling facilities seeks top caliber representation. Particularly interested in developing new industrial plastics applications and volume proprietary lines. Protected terr. Give complete resume, terr. covered and references. Reply Box 6742, Modern Plastics.

POLYESTER RESIN DEVELOPMENT—BS, MS or PhD for work in a new program of research, development, application and market development of unsaturated polyester resins. This is a new program of an established and active company now making other lines of thermoplastic resins. Location is in central research division in Western Pennsylvania. Send complete resume and present salary to Box 6745, Modern Plastics.

FIELD APPLICATION ENGINEER B.S. graduate, preferably Chemical Engineer. Position involves bench work and customer contact in the applications development of resin uses in the construction field. This includes both highway and industrial applications. Knowledge of construction materials an asset. Must be a practical man. Full salary during training. Open position is in the large new epoxy resin technical service laboratory operated for Ciba Products Corp. by the Toms River Chemical Corporation, Toms River, New Jersey.

WANTED—PLASTICS ENGINEER for engineering position with national company, plant in Pennsylvania. Degree in Chemical or Mechanical Engineering required. Experience in pipe extrusion, quality control functions, and plant engineering desirable. Liberal company benefits. Send complete resume and salary requirements to Box 6747, Modern Plastics.

INDUSTRIAL SALES ENGINEER Nationally known Eastern manufacturer of converting and web handling machinery has immediate opening in Chicago Branch Office for aggressive sales engineer between ages of 24-45. Should have a proven record of successful technical equipment in sales in paper, rubber or plastics field, preferably with M.E. or E.E. background. Submit resume giving full details on background, experience, education. Salary and commission open for man with ability and experience to take over as District Sales Manager. Reply Box 6740, Modern Plastics.

NEW ENGLAND FIRM interested in obtaining services of a man familiar with laminating of foam to fabrics. Excellent opportunity for right man. Reply Box 6779, Modern Plastics.

NATIONAL ORGANIZATION seeks engineer to evaluate and render advice on alternative materials and manufacturing processes involved in design of modern sporting firearms. Some experience or interest in firearms desirable but not necessary. Should have thorough training in the properties of all important engineering materials and preferably some experience with attendant manufacturing problems. Small but well established company with considerable growth record. Located in area with particularly fine climate and living conditions. Send resume and recent photograph. Box 6739, Modern Plastics.

(Continued on page 250)

YOU NEVER MADE SO MUCH BEFORE!

Now, a superior way to increase the production and profits from compression or transfer molding presses

Thermall Preheaters are used by most compression and transfer molders. The reasons are simple! Thermall Preheaters (available in either standard or automatic models) not only represent a lower initial investment but also give superior performance. And superior performance means **increasing your production** while **decreasing your production costs.**

Because of its superior design, a Thermall Preheater will heat loose powder or preforms uniformly, quickly and economically and will give you day in and day out performance, around the clock, with the absolute minimum of maintenance.

With a Thermall you will get a reduction in rejects, be able to mold larger parts and increase production as much as 200% (such results have been reported from actual jobs).

YOU CAN RENT!

If you find that renting fits in better with your operation — rent one or more Thermall Preheaters.

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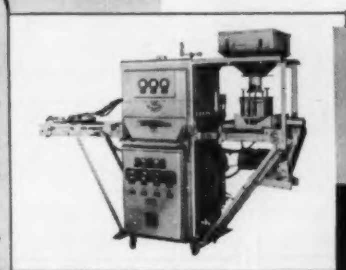

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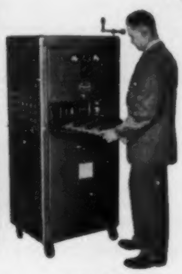

UPRIGHT

THERMALL

W. T. LaROSE & ASSOC., INC.

TROY NEW YORK

(Continued from page 248)

PLASTICS ENGINEER—To take technical responsibility for existing injection molding department and toolroom and to set up a compression molding operation, also participate in new product development. We offer salary commensurate with experience and excellent growth prospects with a Northern N. J. Mfg. of electromechanical products. Reply Box 6774, Modern Plastics.

WANTED — MANUFACTURER REPRESENTATIVES—Well established mid-west custom molding plant doing transfer, compression, and injection work seeks top calibre representation. Would like to expand in the Michigan, Ohio and Indiana area; also the Kansas, Missouri area. Protected territory on a straight commission basis. Give complete resume, territory covered and references. Reply Box 6781, Modern Plastics.

PULP MOLDING—Company entering structural pulp molding field has openings in R&D. Excellent prospects. Salaries open. CHEM. ENGR. (Equivalent experience) in field of Polymers-Resins-Bitumastic and other binders. ENGINEER (equivalent experience) with pulps, its properties, characteristics, and processing. Also TECHNICIANS. Send one page resume. Lesheim, Hillenbrand Industries, Batesville, Indiana.

Situations Wanted

WESTERN REPRESENTATIVE WANTS—Additional top quality line for west coast or 10 western states. Present accounts are tooling. From commercial to missile quality. Trades are: plastic molders, Inj., Comp., and blow. Die casters, Aluminum and zinc. Tool and die shops. Precision pattern and model shops working with brass and lucite; castable epoxies, rubber and plasters. Reply Box 6749, Modern Plastics.

ATTENTION PLASTICS MANUFACTURERS—It takes initiative, imagination and infectious enthusiasm to enlist top caliber college graduates. It takes more of the same to hold them and even more to inspire them to be productive. Let me show you why I qualify. Reply Box 6748, Modern Plastics.

MANUFACTURERS REPRESENTATIVE—Specializing in custom plastic products since 1953 to O.E.M., Military & Utility companies in Middle South area, desires one or two additional plastic related accounts with reputation of high quality and competitive prices. Reply to Box 36, Roanoke, Virginia.

ENGINEER-MANAGER — Broad experience with administrative and operational background. 20 years experience covers compression and injection molding—sheet extrusion and vacuum forming—reinforced plastics and filament winding. Experienced in engineering and sales of automotive, O.E.M., Aircraft and missile parts. Presently engaged in development of missile components. Seeks position utilizing capabilities. Reply Box 6755, Modern Plastics.

YOUNG AMERICAN EXECUTIVE—General Manager of successful high production polyethylene film and pipe extrusion plant in Central America desires U. S. employment. Trained and experienced in plant installation, production and management. Complete resume on request. Reply Box 6756, Modern Plastics.

PLASTIC SALES ENGINEER BSME, Reg. Prof. Eng. 12 years plastic experience includes thermoplastic and thermosetting product and equipment design. Some foam, fiberglass, vacuum forming, extrusion, blow and rotational molding experience. Seek position with equipment or material manufacturer. Reply Box 6762, Modern Plastics.

PLANT MANAGER—10 years experience compression, injection, transfer, tools design, sales finishing. Licensed pilot. Complete resume on request. P. O. Box 6743, Modern Plastics.

PLASTIC CO-OP MOLDING MANAGER—Looking for three volume buyers of plastic molded items, who are interested in starting their own molding plant. I am heavy in engineering and production experience, low in capital. I know that a co-op molding plant will aid all concerned. Experience in toys, housewares, pipe fittings and industrial moldings. Location northern Ohio and Indiana. Reply Box 6760, Modern Plastics.

SALES MANAGER AND ENGINEER—12 years experience working with and managing sales for extruded and molded products. Now managing sales for all types of plastic pipe, fittings, and custom work. Desire position as plant manager or sales manager with a progressive company. Can re-locate anytime. Reply Box 6759, Modern Plastics.

PLASTIC VALVES AND PIPE FITTINGS—Interested in obtaining position with metal pipe fitting mfg. who is planning expansion to a plastic line. Capable of handling from idea to finished product. 12 years plastic experience. BSME, Reg. Prof. Eng. Reply Box 6758, Modern Plastics.

CHALLENGE WANTED—Registered Engineer, age 33, 11 years varied experience in injection molding/vacuum forming and heavy construction. Available February. Have sold services, products, acted as purchasing agent, field engineer, chief estimator, expediter, mold designer, plant manager and corporate treasurer. Reply Box 6778, Modern Plastics.

PACKAGING SALES is my field. Supervisory and Management experience. Five years with polyethylene converter, four years vacuum process packaging. Experienced in field application, development, production line, public relations. B.S. degree in Economics. 41, married, with four incentives. Denver and Rocky Mountain area preferred. Reply Box 6775, Modern Plastics.

Business Opportunities

HAND COMPRESSION plastic molding wanted. Short runs a specialty—located Long Island. Box No. 6773, Modern Plastics.

PRESS TIME AVAILABLE—Large Midwest Firm has opening on 40 oz. machine for long time contract at $9.00 per hour. Reply Box 6741, Modern Plastics.

EXPORT DISTRIBUTION—Long established and experienced U.S. plastic organization desires representing reliable manufacturers with a view to exporting their goods on a sole-selling basis. Please write in confidence to Box 6769, Modern Plastics.

ENGLAND — PLASTIC/PAPER Coating and foil/film/paper laminating company seeks to contact American organisation interested in having their specialty products manufactured and marketed in G.B. and Europe. We are a vigorous, fast-growing concern established since 1942 with modern plant and an aggressive and successful sales organisation. Leonard Stace Limited, Gloucester Road, Cheltenham, Glos.

PRESS TIME OPEN—We can mold your Fiberglas product for you using preform or mat technique. Press capacity up to 150 tons—36x48 bed. Contact J. B. Quinn, Brunswick Corporation, School Equipment Division, 2605 East Kilgore Road, Kalamazoo, Michigan.

WANTED TO BUY—Interested in purchasing all or part of injection molding shop, in New England Area. Reply Box 6744, Modern Plastics.

CANADA—EXTRUSION SALES—Engineering sales organization selling custom engineered items to Canadian industry, with offices in Toronto and Montreal, wishes to contact reputable U.S. custom extrusion house interested in the Canadian market. Both offices staffed by graduate mechanical engineers with M.I.T. degrees in Business Administration. Box No. 6746, Modern Plastics.

MODERN—complete, plastic decorating plant. Well established, excellent accounts. Producing year round at near capacity. Present capacity sold out for 1961-62 model year. Work primarily automotive. Room and opportunity for expansion limited only by desire to expand. Ideally located. Profits excellent and consistent. Minimum cash required $165,000. Would take stock in rated company, if necessary, on balance. Principals only please. Reply Box 6750, Modern Plastics.

Miscellaneous

VACUUM METALIZING OPEN TIME AVAILABLE—Equipment includes 48" Bell, Ovens, and facilities for spray and Flo-Coat Painting, Mask and Fixture Fabrication, Printing, Assembly, Packaging, and Warehousing. Close liaison with Automotive Industry. Experienced in Prototypes, Delrin, Implex, Cyclac, Styrenes, etc. Sparling Plastic Industries Inc., 1730 Howard St., Detroit 16, Mich.

WANTED — Partnership with small molder, preferably one making consumer goods. Offer extremely fertile imagination for practical applications, new ideas that can be executed, previous sales experience. Company should be located in Northern New Jersey area. Reply Box 6780, Modern Plastics.

CONTRACT WORK WANTED—Plastics compression molder desires contract work. Good opportunity if you can use our facilities. Good labor. Modern Plant. Located vicinity New York City. Write Box 6782, Modern Plastics.

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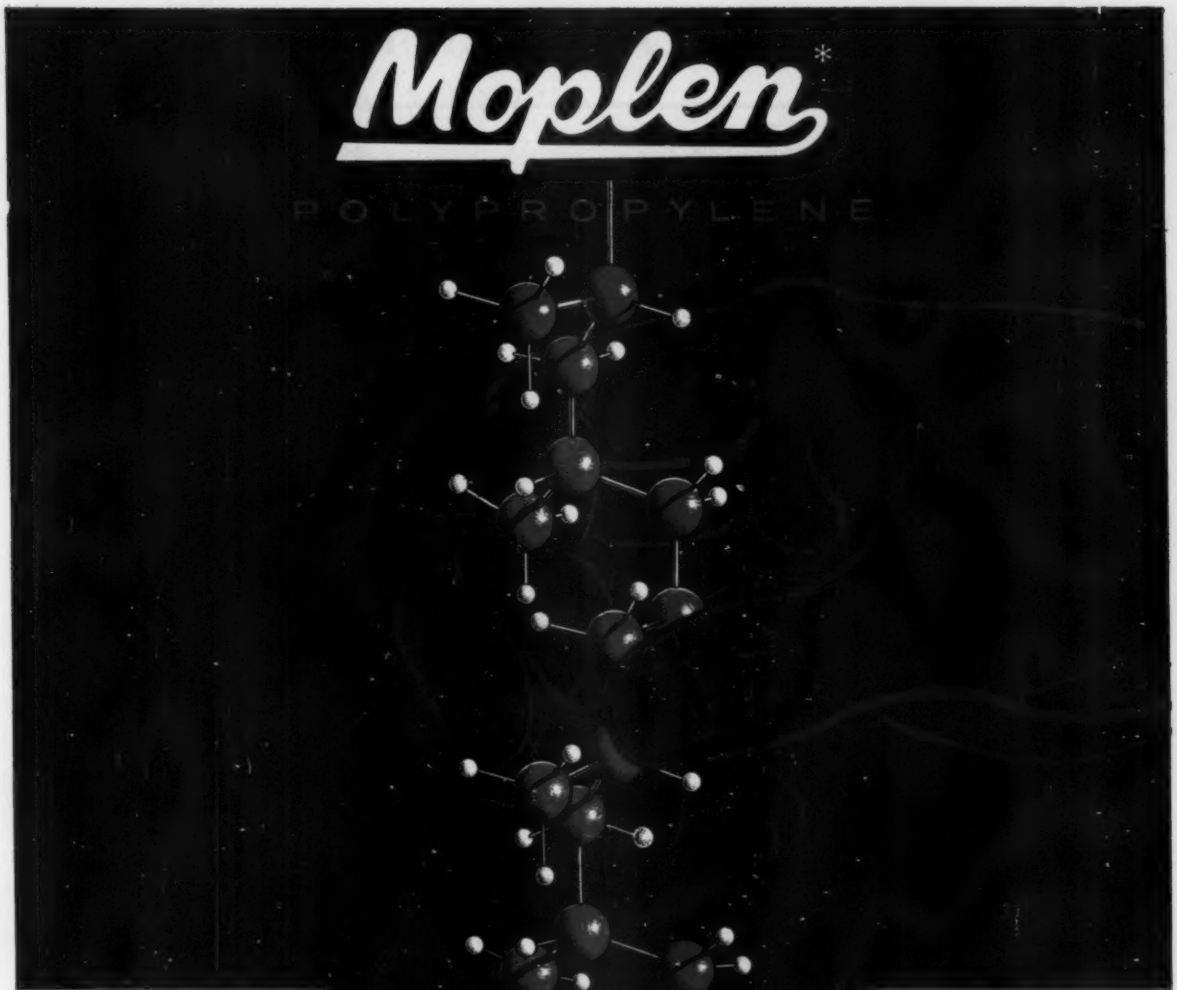
All classified advertisements payable in advance of publication

Closing date: 10th of preceding month, e.g., January 10th for February issue
Per inch (or fraction) .. $30.00; each 3 inches or fraction (in border) $15.00 extra

Situations Wanted Ads ... 1/3 of above rates

For purpose of establishing rate, figure approximately 50-55 words per inch. For further information address Classified Advertising Department. Modern Plastics, 575 Madison Avenue, N. Y. 22, N. Y. Modern Plastics reserves the right to accept, reject or censor classified copy.



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Leader in this conquest of inner space is Montecatini, who developed the first stereospecific polymer, MOPLEN® polypropylene. The forerunner of a revolutionary class of plastic materials discovered by Giulio Natta of the Polytechnic Institute of Milan, MOPLEN® is being widely used in Europe and in the United States.

Montecatini continues to explore this new world of structural chemistry . . . is developing new polymerization catalysts and producing new polymers with exciting potential as plastics, textile fibers and elastomers in the products of tomorrow.

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INDEX OF ADVERTISERS

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MODERN PLASTICS

A BRESKIN PUBLICATION

PUBLISHED BY BRESKIN PUBLICATIONS INC. 575 Madison Avenue, New York 22, N. Y.

MORE AND MORE INJECTION MOLDERS ARE INCREASING PRODUCTION WITH THE DE MATTIA 12/16 OZ MODEL M-1

Fully hydraulic, completely automatic (with prepack), 12 dry cycles per minute, low pressure closing . . . these and the many other features of the De Mattia 12/16 oz. Model M-1 add up to proven production increases of up to 20 per cent. Write for complete details, specifications.

PLASTICIZING CAPACITY	150 lbs./hr.
MAXIMUM DAYLIGHT	32"
CLAMPING PRESSURE	400 tons
MAXIMUM MOLD SIZE	20" x 30" horiz. 16" x 32" vert.

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EDITORIAL

All plastics shows are international!

With the National Plastics Exposition coming up in New York next June, to be followed by the British Plastics Exposition, it might be well for exhibitors to plan their *modus operandi* so as to achieve the best results from their expenditures in terms of international attention and understanding.

Modern Plastics reports in this issue on the macroPlastic Exhibit held in Holland in October. Not reported in that script are some mistakes made by exhibitors, generally, which may be avoided in the aforementioned 1961 shows.

1. All handout descriptive literature should be available in the languages of all the countries with which the exhibitor is doing or intends to do business.

2. A list of distributors or commission representatives for the various countries concerned should be available, possibly in the form of an easel card.

3. Booths or stands should not be staffed exclusively by junior salesmen not well acquainted with the machinery or the materials exhibited and not authorized to make decisions. At least a salting of senior executives should always be present.

4. Where a company has deep interests in markets in certain foreign countries, it might be well to have on hand at certain hours multi-lingual translators. These should be briefed well enough technically to be of service. Such people are quite available in both New York and London.

5. Special attention should be paid by exhibitors to the interested foreign and domestic industrial reporters and editors. Releases, like the brochures, should be available in the languages of the countries with which the exhibitor is concerned and should be accompanied by glossy photographs, preferably 8 by 10 in. but certainly not smaller than 5 by 7 in., properly captioned. In the case of press information on new equipment, the photographs should not just show the exterior of the machine and its accompanying control panels. Rather, releases should contain housing-off close-ups of the mechanical operation of the entrails of the machine plus, if at all possible, cutaway isometric drawings.

6. In the case of plastics materials, new and important applications should be stressed, of course. But in support there should be definitive material available on engineering and design factors and on the most efficient processing methods for those plastics. Again, such information should be available in some usable form on a multi-lingual basis.

Hiram McCann